Brain Machine Interface for Controlling a Robotic Arm

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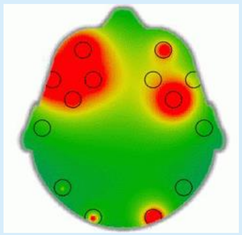
Cognitive Thought Recognition

- Test different thought patterns and determine the best method of creating and detecting unique brainwave signatures.
- Create a universal folder (one folder containing 5 subject's data) and test this against the individual subject's folder.
- Examine the feasibility of using pure electroencephalograph (EEG) data in conjunction with EEG facial expressions.

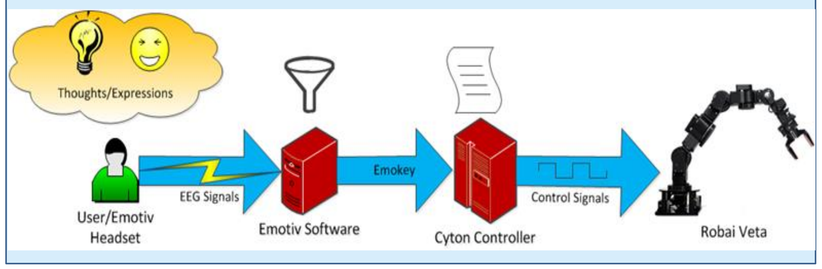


Raw Data Acquisition

- The Emotiv EPOC Headset is a high resolution multi-channel wireless neuroheadset that is primarily used to collect the raw EEG signals using three fundamental suites (Expressiv, Affectiv, and Cognitiv).
- Use Emotiv software for gathering, displaying, and analyzing EEG data.
- The Expressiv Suite uses the signals detected by the neuro-headset to measure the user's real-time facial expressions.
- The Affectiv Suite monitors the user's real-time emotional state.
- The Cognitiv Suite reads and interprets the user's thoughts and intentions.
- 14-channel EPOC headset provides high temporal resolution and strategic positioning provides sufficient high spatial resolution.

System Overview

- Train emotional state of a user for the system to recognize the user profile.
- Using an Emotiv EPOC headset, collect raw EEG signals from the user to detect cognitive and expressive actions.
- The system maps collected signals to predefined signals and selects an appropriate action.
- The software encodes the action and sends it to a console that manipulates the robotic arm.



Procedure

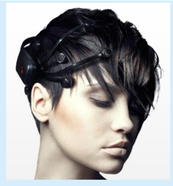
- Identify and program an action for the Robotic arm to perform.
- Connect Robotic action to specific thought.
- Have Emotiv software detect user thought patterns for each specific action.
  - Train individual profile with thought-action combinations.
  - Train universal profile for the same thought-actions.
- Test and compile data for several thought-action patterns with the software interface.
- Fine tune the confidence and threshold values to best suit the user's thought patterns to allow for better detection.

Various Actions to Map

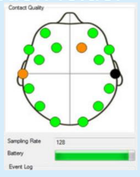
•Pure EEG:
- Thinking Left and Right ⟶ Rotate the Base (Left & Right)

•Facial Expressions through EEG:
- Smirking Left and Right ⟶ Wrist Movement (Left & Right)
- Raising Eyebrows ⟶ Pushing action
- Looking Left ⟶ Pulling action
- Jaw Clench ⟶ Closing and Opening Gripper

Data Acquisition



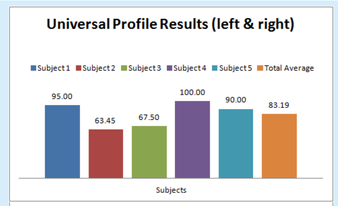
- Individual
  - Gather data for individual subject
  - Each subject trains multiple actions
- Universal
  - Gather data for all subjects
  - Five subjects train multiple action in universal action folder
- Testing round 1
  - 2 EEG actions (Left & Right)
- Testing round 2
  - 2 EEG actions (Left & Right)
  - 2 Facial Expressions (Left Smirk & Right Smirk)
- Testing is still in progress

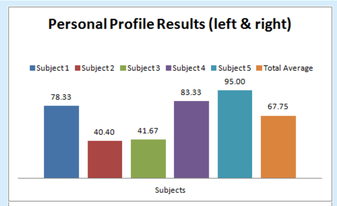


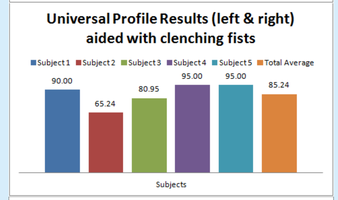
System Evaluation

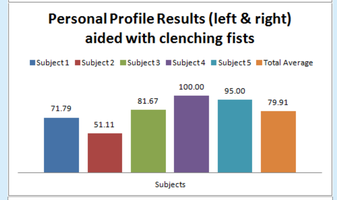
1. Two rounds of testing were done
   - 2 EEG actions and 2 Facial Expressions combined.
1. Based on the results compiled from both tests, the Universal data folder showed improvement of the system's accuracy in determining which action was desired from the subject.
2. Additionally, results obtained from data collected using pure EEG thoughts aided with physical muscle tension improved signal accuracy.
3. Further testing the implemented filter proved viable to the overall real-time accuracy of the system and filtering unwanted actions misinterpreted by the system.
4. System detection of facial expressions, when combined with cognitive Pure EEG signals, occurred more frequently which decreased the system's overall accuracy.

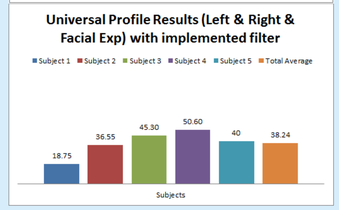
Experimental Results

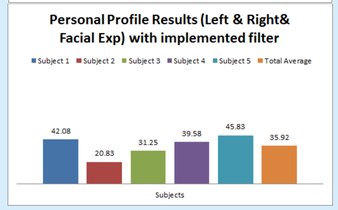












Applications and Future Research

The EEG Brain Machine Interface could be applied to help disabled individuals use robot(s) to complete various laborious tasks, or aid the user through EEG signals in controlling multiple modern devices such as Google Glass, cell phones, electric wheelchairs, air conditioners, etc...
Another interesting application would be the development of a brain computer interface based neurofeedback system to evaluate human perception under stressed environments.