BCI Research at the Wadsworth Center: Developments in Noninvasive Communication and Control

Dean J. Krusienski
Assistant Professor
Electrical Engineering
University of North Florida
The Wadsworth BCI Lab

- Located in Albany, NY
- Part of the New York State Dept. of Health
- Lab Chief: Jonathan Wolpaw
- ~20 Research Scientists, Postdocs, Technicians, & Students
- Mission: To research and develop BCI technology for helping severely disabled individuals communicate and interact with their environments.
Wadsworth BCI Milestones

- 1986: Preliminary BCI studies supported by IBM
- 1991: First demonstration of EEG-based 1d cursor control in humans
- 1994: First demonstration of EEG-based 2d cursor control in humans
- 2004: First demonstration of an ECoG-based BCI in humans
- 2004: Demonstration of refined 2d cursor control in humans
- 2006: Home System – first demonstration of long-term, everyday BCI use by a disabled individual in his home
- 2009: First demonstration of EEG-based 3d cursor control in humans (to appear)
- Present: Large-scale BCI testing and dissemination to disabled populations
Wadsworth’s Approach

- **P300 Evoked Potentials**
  - Special interface designed to exploit discrete responses for symbol selection
  - Innate, no training required
  - Low SNR: Typically require averaging of multiple responses
  - Applications: discrete symbol selection for word processing or environmental control

- **Sensorimotor Rhythms (SMR)**
  - Users can be trained to accurately modulate amplitudes of rhythms for real-time, continuous dimensional control
  - Applications: continuous cursor control, navigation, robotic/prosthesis control
P300 Matrix Speller

Waiting to start ...

interval between stimuli = 125 ms
selections = 12
selections / min = 7.13
bits / min = 43.98 / 56.21*
*time between selections omitted
P300 Evoked Potential
P300 Processing

Mean Accuracy

Offline                         Online

# Flashes

 Offline

 15 15 10 5 10

 5 10 15

Online

 15 10 5 5 10

 5 10 15

100

80

60

40

20

Krusienski et al, J Neuro Meth 2008
P300 Processing

- 800ms Responses
- Smooth and Decimate to 20Hz
- Stepwise Linear Discriminant Analysis

\[
\text{predicted row} = \arg \max_{\text{rows}} \left[ \sum_{i_{\text{row}}} w \cdot f(x_{i_{\text{row}}}) \right]
\]

\[
\text{predicted column} = \arg \max_{\text{columns}} \left[ \sum_{i_{\text{column}}} w \cdot f(x_{i_{\text{column}}}) \right]
\]
P300 Home System

Scott Mackler MD, PhD
University of Pennsylvania
School of Medicine
SMR: 2D Cursor Control
Sensorimotor Rhythms
SMR Processing
SMR Processing

- Large Laplacian Spatial Filter
- 16\textsuperscript{th} Order Autoregressive Spectrum Estimation
- LMS Adaptation of Feature Weights

\[ \Delta_{xy} = K \left( \sum_{f_L} w_L^f A_L^f + \sum_{f_R} w_R^f A_R^f + b \right) \]
Mouse Emulation

McFarland et al, J Neural Eng 2008
Robotic Arm
Present and Future

- Refine P300 & SMR Control
- Home System
  - Practical Considerations: Software & Maintenance
- 3-D/N-D EEG-Based Control
- ECoG
  - Attention
  - Speech
  - Motor Activity
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