

Controlling Robots with Non-Invasive Brain-Computer Interfaces

Elliott Forney

Colorado State University
Brain-Computer Interfaces Group

February 21, 2013



Brain-Computer Interfaces

- Brain-Computer Interface (BCI)
- Direct channel of between brain and machine
- Voluntary changes in mental state
- Bypasses innate motor-based means of communication



Brain-Computer Interfaces

- Brain-Computer Interface (BCI)
- Direct channel of between brain and machine
- Voluntary changes in mental state
- Bypasses innate motor-based means of communication



Uses for BCI

- **BCI have many potential uses**
- Reestablish communication with people who are Locked-in
 - ALS, stroke, traumatic brain injury
- Assistive technology
 - electric wheelchairs, computers, telephones
- Everyday devices
 - video games, monitoring emotional states
- Driving kewl robots around the lab with your mind!

Uses for BCI

- BCI have many potential uses
- Reestablish communication with people who are Locked-in
 - ALS, stroke, traumatic brain injury
- Assistive technology
 - electric wheelchairs, computers, telephones
- Everyday devices
 - video games, monitoring emotional states
- Driving kewl robots around the lab with your mind!

Uses for BCI

- BCI have many potential uses
- Reestablish communication with people who are Locked-in
 - ALS, stroke, traumatic brain injury
- Assistive technology
 - electric wheelchairs, computers, telephones
- Everyday devices
 - video games, monitoring emotional states
- Driving kewl robots around the lab with your mind!

Uses for BCI

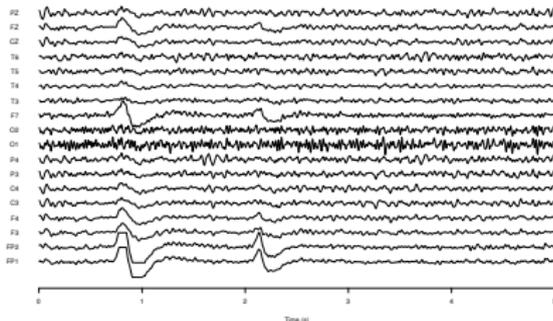
- BCI have many potential uses
- Reestablish communication with people who are Locked-in
 - ALS, stroke, traumatic brain injury
- Assistive technology
 - electric wheelchairs, computers, telephones
- Everyday devices
 - video games, monitoring emotional states
- Driving kewl robots around the lab with your mind!

Uses for BCI

- BCI have many potential uses
- Reestablish communication with people who are Locked-in
 - ALS, stroke, traumatic brain injury
- Assistive technology
 - electric wheelchairs, computers, telephones
- Everyday devices
 - video games, monitoring emotional states
- Driving kewl robots around the lab with your mind!

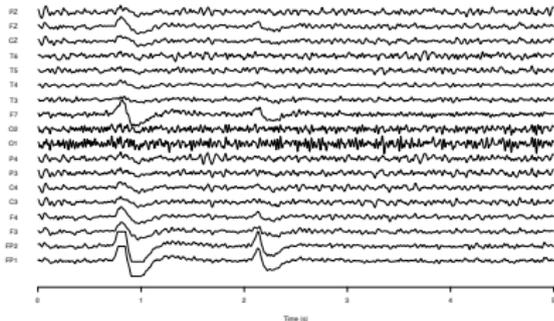
Electroencephalography

- Electroencephalography (EEG) to measure brain activity
- Non-invasive, portable, relatively inexpensive
- Superficial & noisy signals



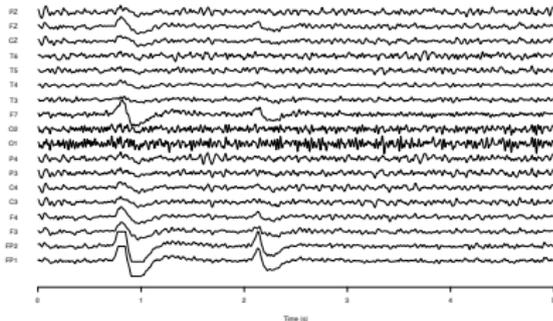
Electroencephalography

- Electroencephalography (EEG) to measure brain activity
- Non-invasive, portable, relatively inexpensive
- Superficial & noisy signals

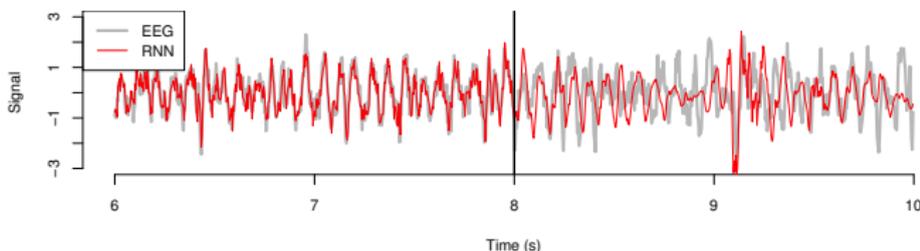


Electroencephalography

- Electroencephalography (EEG) to measure brain activity
- Non-invasive, portable, relatively inexpensive
- Superficial & noisy signals

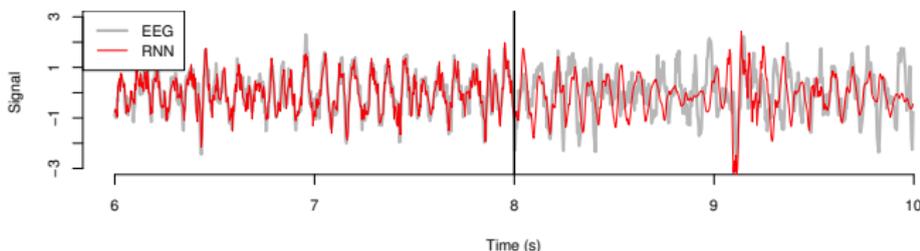


- Machine Learning algorithms identify patterns in EEG
- This is **extremely** difficult because
 - different for each person
 - change over time
 - noise & artifacts
 - the brain is complex!



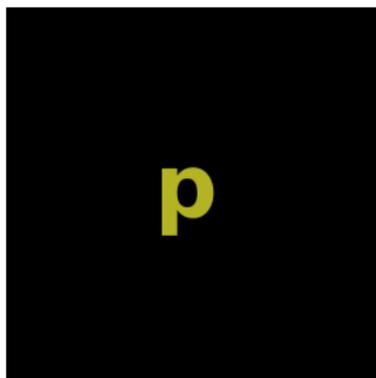
Machine Learning & Pattern Analysis

- Machine Learning algorithms identify patterns in EEG
- This is **extremely** difficult because
 - different for each person
 - change over time
 - noise & artifacts
 - the brain is complex!



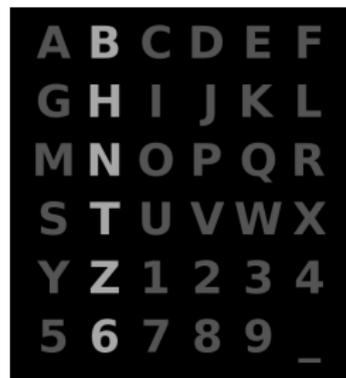
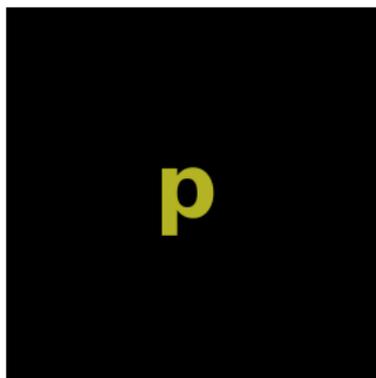
Synchronous BCI

- Some BCI use patterns associated with external stimuli
- P300 speller is an example
- User looks for a specific character in a series or grid of flashing characters



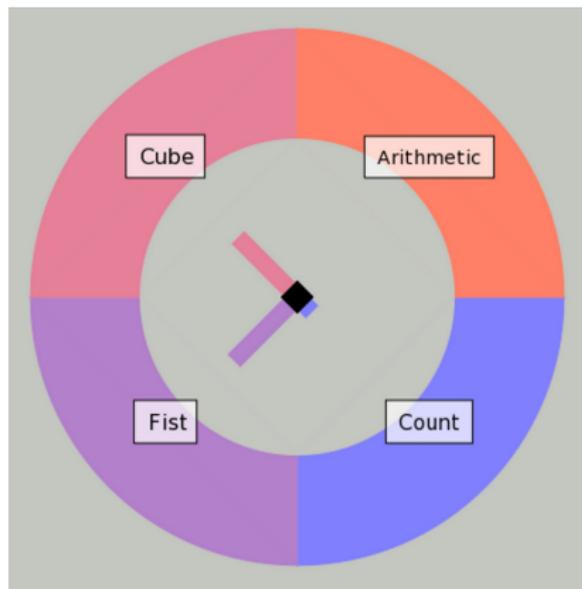
Synchronous BCI

- Some BCI use patterns associated with external stimuli
- P300 speller is an example
- User looks for a specific character in a series or grid of flashing characters



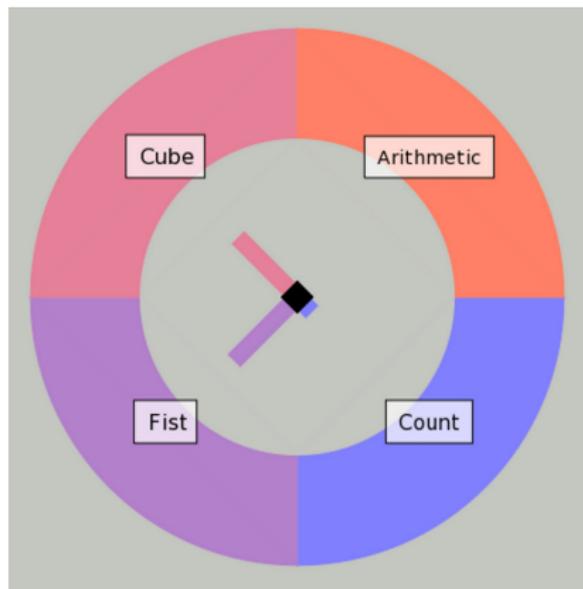
Asynchronous BCI

- Other BCI do not require external stimuli
- Mental Tasks is an example
- Imagine left arm moving moves to the left while silently singing a song moves to the right



Asynchronous BCI

- Other BCI do not require external stimuli
- Mental Tasks is an example
- Imagine left arm moving moves to the left while silently singing a song moves to the right



- Controlling robots is a first step toward real-world applications
- Drive a robot before an electric wheelchair
- Demonstrates that user has control
- Just plain fun!

Robots

- Controlling robots is a first step toward real-world applications
- Drive a robot before an electric wheelchair
- Demonstrates that user has control
- Just plain fun!

Ideas for Robot Club, I

- Current robot module is hacked together but better systems to come.
- Some ideas for robot club to start on
- Streaming video through sockets, to python
- Better user interfaces
 - Fluid control
 - How far to move
 - Control gripper

Ideas for Robot Club, I

- Current robot module is hacked together but better systems to come.
- Some ideas for robot club to start on
- Streaming video through sockets, to python
- Better user interfaces
 - Fluid control
 - How far to move
 - Control gripper

Ideas for Robot Club, I

- Current robot module is hacked together but better systems to come.
- Some ideas for robot club to start on
- Streaming video through sockets, to python
- Better user interfaces
 - Fluid control
 - How far to move
 - Control gripper

Ideas for Robot Club, I

- Current robot module is hacked together but better systems to come.
- Some ideas for robot club to start on
- Streaming video through sockets, to python
- Better user interfaces
 - Fluid control
 - How far to move
 - Control gripper

Ideas for Robot Club, II

- Safety systems
 - Don't hit a wall
 - Don't go down stairs
- Hybrid control
 - Turn away from walls
 - Move toward objects

Ideas for Robot Club, II

- Safety systems
 - Don't hit a wall
 - Don't go down stairs
- Hybrid control
 - Turn away from walls
 - Move toward objects

Thanks!

