A Brief Introduction to Non-Invasive Brain-Computer Interfaces

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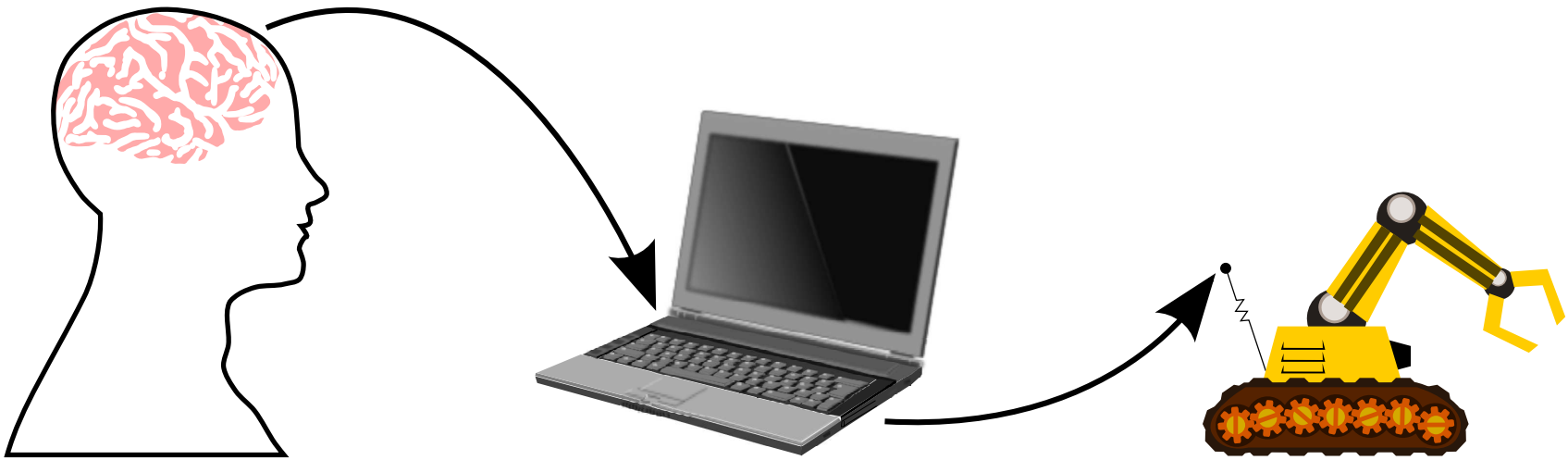
Brain-Computer Interfaces

- Brain-Computer Interface (BCI)
- Direct communication between brain and machine
- Bypasses innate motor-based means of communication
- Control a computerized device using only thoughts
- Voluntary changes in mental state, not mind reading!
- Uses patterns associated with mental cues

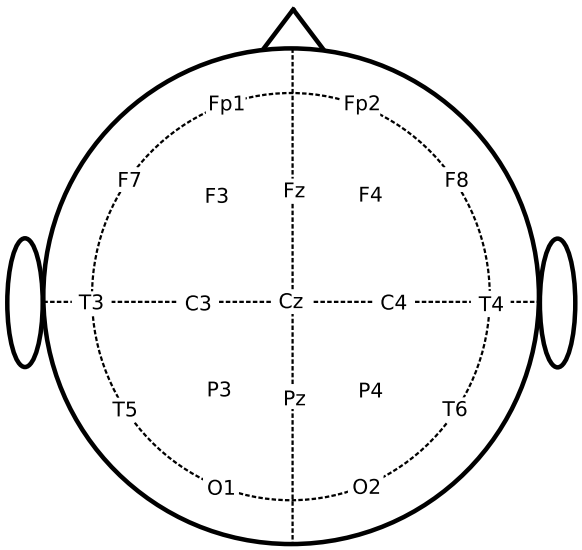


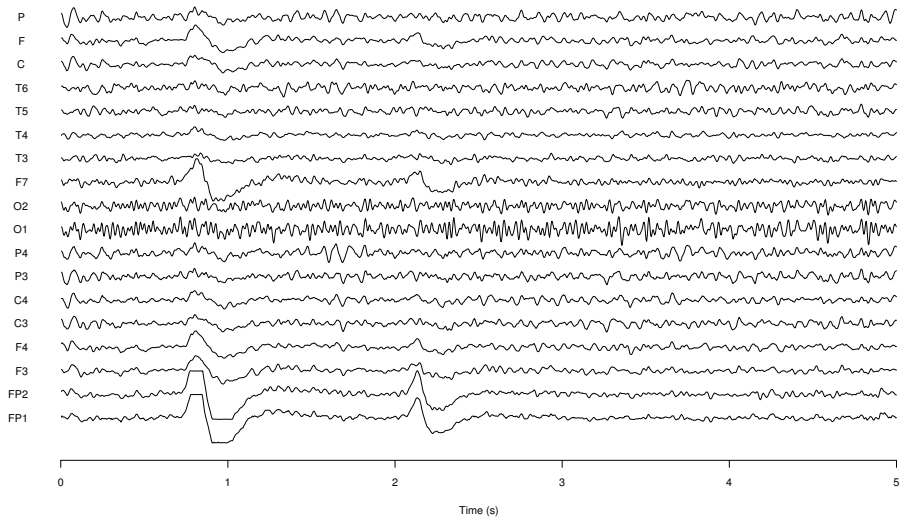
Uses for BCI

- BCI have many potential uses
- Reestablish communication with people who are Locked-in
  - Aware and cognitive function but unable to communicate
  - ALS, stroke, traumatic brain injury
- Assistive technology
  - electric wheelchairs, computers, telephones
- Everyday devices
  - video games, monitoring emotional states

Electroencephalography

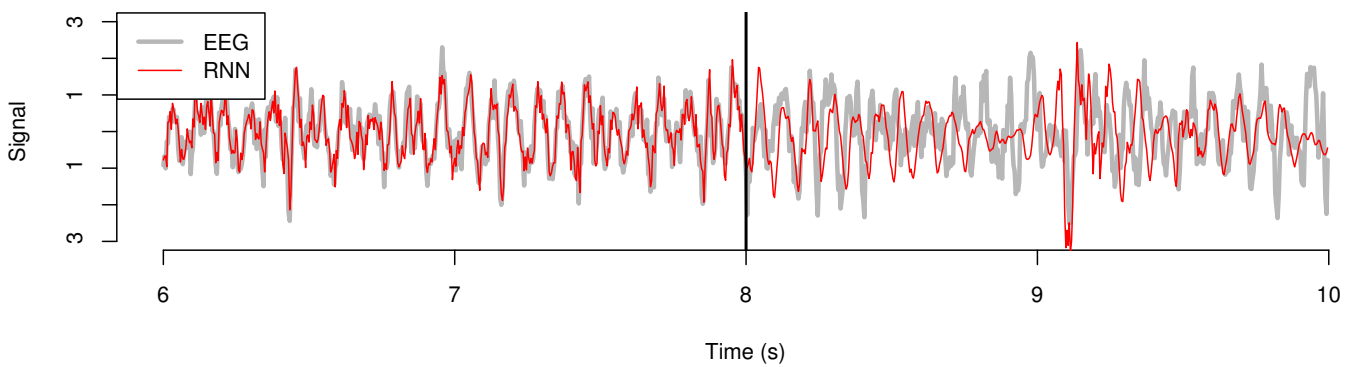
- Electroencephalography (EEG) to measure brain activity
- Non-invasive, portable, relatively inexpensive
- Superficial & noisy signals





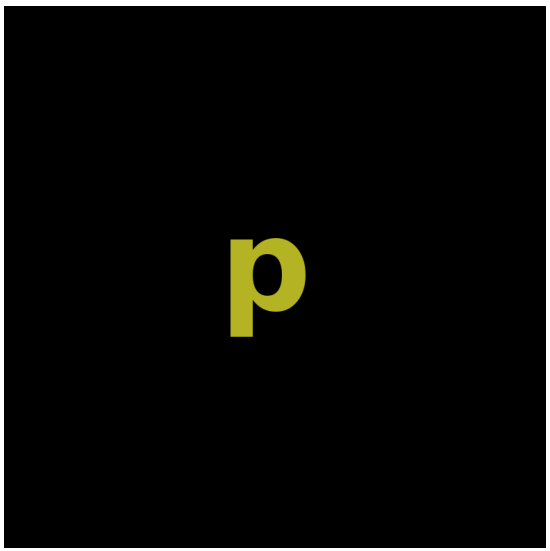
Machine Learning & Pattern Analysis

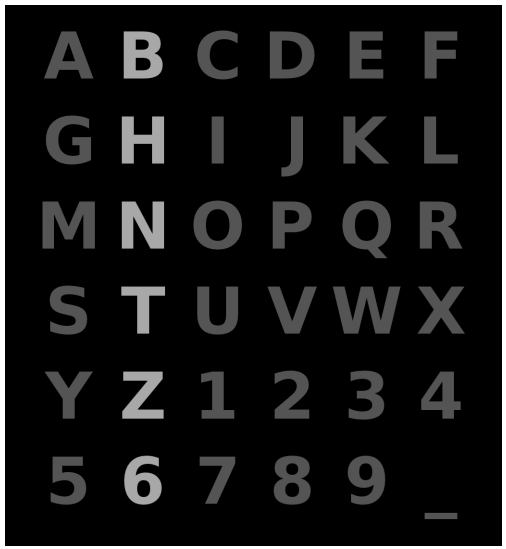
- Machine Learning algorithms identify patterns in EEG
- This is **extremely** difficult because
  - different for each person
  - change over time
  - noise & artifacts
  - the brain is complex!



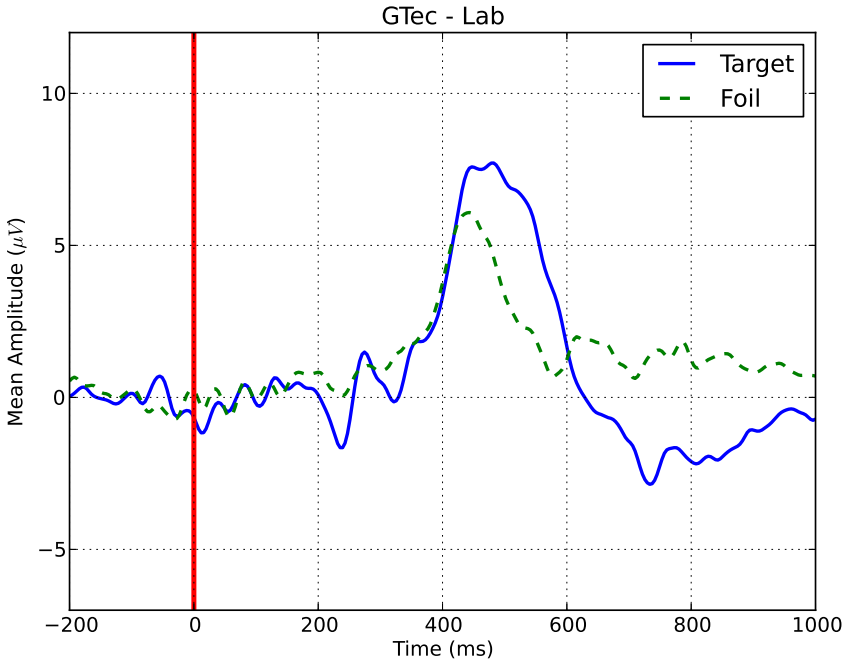
Synchronous BCI

- Synchronous 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



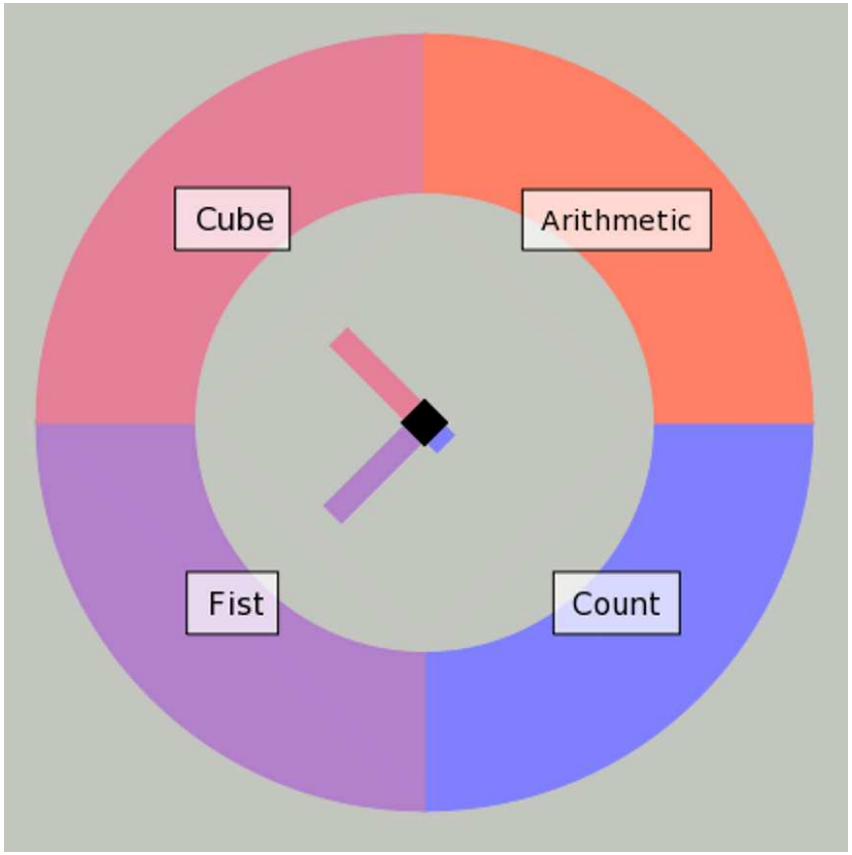


P300 Plot


GTec - Lab
Target
Foil
Mean Amplitude (μV)
10
5
0
−5
−200
0
200
400
600
800
1000
Time (ms)

Asynchronous BCI

- Asynchronous 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



Future of BCI

- Explosion of BCI research in recent years
- Currently testing BCI in real-world conditions and with users that have motor impairments
- Portable, low-cost, easy-to-use EEG systems being developed
- Obama just launched $100M BRAIN iniative
- Personal prediction: BCI will be commonplace in 10 years

Thanks!