I will be in ECE tomorrow

LECTURE 5

Brain-Computer Interface. (chap 3, Bin He).

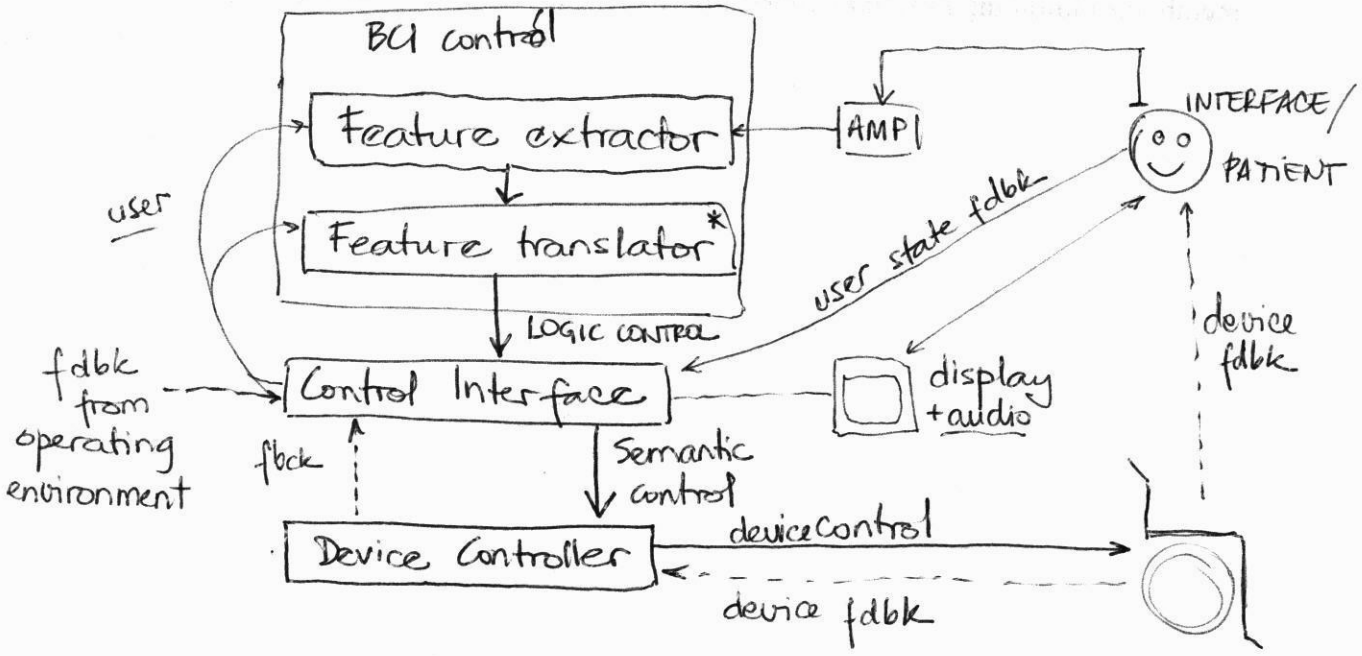
Def.: method of communication based on neural (brain-generated) activity INDEPENDENTLY of its (usual) normal output pathways.

Goal: provide new channel of output!

BCI is restricted to VOLUNTARY control.
(counter example: Parkinson's - implants are NOT BCI!)

Application: to help individuals with mild to severe muscular handicaps.

Block diagram of a model BCI system:



*Classifier

Requirements:

* synchronization
* real time (w/ continuous feedback).
* reliability
* adaptive feature extraction.
* customized interface

Examples of successful experiments with INVASIVE techniqu

① Nicolelis 2003, Nicolelis + Chapin 2002.
- monkeys w/ depth EEG recordings. 3D movement of arms in space + gripping.

② Pfurtscheller 2003. / Levine 2000.
- Subdural electrodes (ECoG) placed for epileptic surgeries (not controlled by the BCI research requirements)
- measured either prompt-paced or self-paced movements.
- 90% accurate detection of ERPs (event-related-potentials) → see next pages.

BOTTLENECKS:
- we can't measure ALL neurons.
- even if we could, we don't know the CODE.

Noninvasive techniques

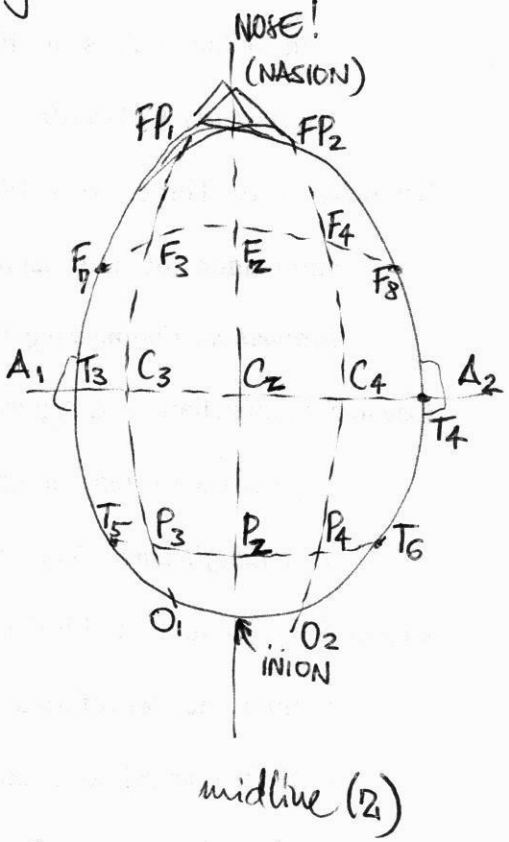
- EEG: ubiquitous, easy instrumentation.
- Imaging techniques: still too expensive, not widely available.

EEG: International 10/20 system

FP - prefrontal lobe
F - frontal "
T - temporal "
C - central "
P - parietal "
O - occipital "

Z = zero (midline)
even #: right side
odd #: left side

A = auricular (ear lobe).



(butler.cc.tut.fi/~malmivuo/bem/bembook/in/in.htm)

What does the BCI system need? SIGNALS:

spikes ⟶ APs (reflect single neurons)
field potentials ⟶ combined synaptic, neuronal, and axonal activity of groups of neurons

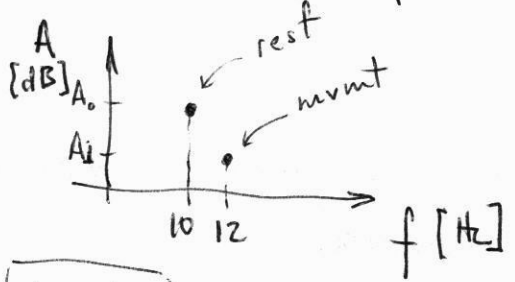
EEG bands – components of interest:

δ	delta	0.5 – 3 Hz	
θ	theta	4 – 7 Hz	
α	alpha	8 – 13 Hz	} majority of BCI research.
β	beta	14 – 30 Hz	}
γ	gamma	30 – 60 Hz	
μ	mu	10 – 12 Hz	

Oscillatory activity:

Synchronized activity generates observable (measurable) oscillations

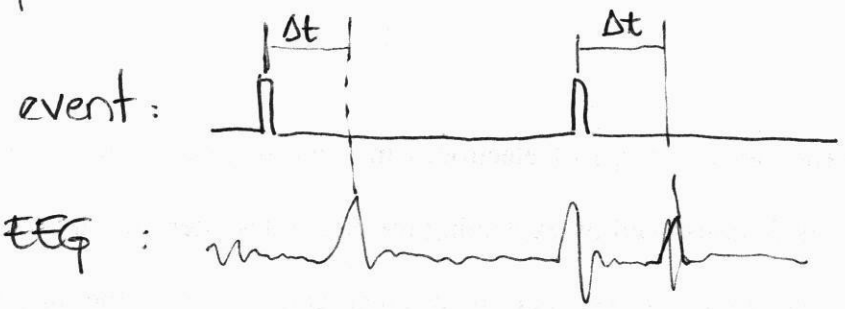
- Rolandic mu-rhythm (10 – 12 Hz)
- Central beta-rhythm (14 – 18 Hz)
  - Both occur continuously during REST.
  - Non-idling: oscillations still there, but w/ higher freq + lower amp



$A_1 < A_0$

EVOKED POTENTIALS (EPs, or
↓ event-related potentials, ERPs)

time-locked responses by the brain at fixed time after a particular event.



EXOGENOUS ERP : due to event, not to the user (not due to processing)
- light → VEP.

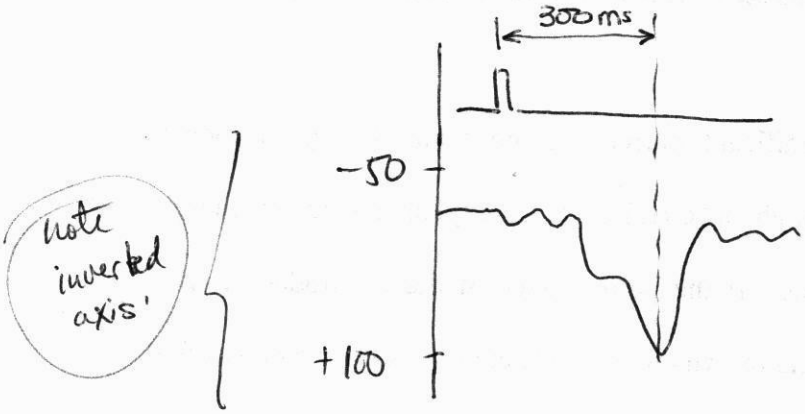
ENDOGENOUS ERP : result of event + intention (processing of the event).
- spelling trials:
  "right" letter → endogenous ERP

— ERD: ER desynchronization: decrease in power in specific freq bands
  ↑ task complexity
  ↑ attention
  ⇒ more ERD

— ERS: ER synchronization
  ↑ power (neurons firing "simultaneously")

VEP: visual evoked potentials: response to visual stimuli. Requires GAZE (muscular control)
- exog. — SSVEP (steady-state VEP)
- endog. — P300 (can be modulated)

P300 (VEP) - 300ms (approx) after event.



P - positive } peaks
N - negative }

P300 amplitude can be modulated (2 categories).

Slow cortical potential:

- caused by shifts in V_m of dendrites.

V_m = membrane potential

(amplitude of 10μV approx - very difficult to measure).

- from 0.5 to 10s after internal event
- depends on cognitive and behavioral performance of subject

Neuronal potentials

- spikes from individual neurons or group of neurons.
- measure of rate, correlation, and temporal pattern of neuronal firing
- better spatial resolution (isolated signals)

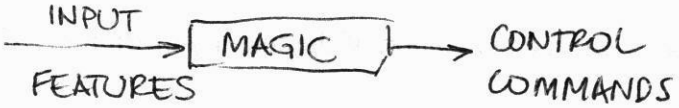
Subject training

- Cognitive tasks : motor movement imagination etc
- Operant conditioning : no specific cognitive task.

Signal Processing.

- Artifacts:
  - "endogenous" - facial muscles, head movement
  - exogenous - acq. system, 60Hz, equipment in the room, etc.

Translation techniques:



TYPOS:

pg 109 – 250ms, not 250m.

pg 111 – http://ece.osu.edu