生醫實驗期中報告 --brain–machine interface (BMI)

第八組
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Introduction

- A brain–machine interface (BMI), sometimes called a direct neural interface or a brain–computer interface (BCI), is a direct communication pathway between the brain and an external device. BMIs are often aimed at assisting, augmenting or repairing human cognitive or sensory-motor functions.

Development

--Early work

- In the 1970s,monkeys could quickly learn to voluntarily control the firing rates of neurons in the motor cortex.
- In the 1980s, Apostolos Georgopoulos at Johns Hopkins University found a mathematical relationship between the electrical responses of motor-cortex neurons in monkeys and the direction that monkeys moved their arms.

Development

--Prominent research successes

- cortical neurons directly control a robotic manipulator in 1999

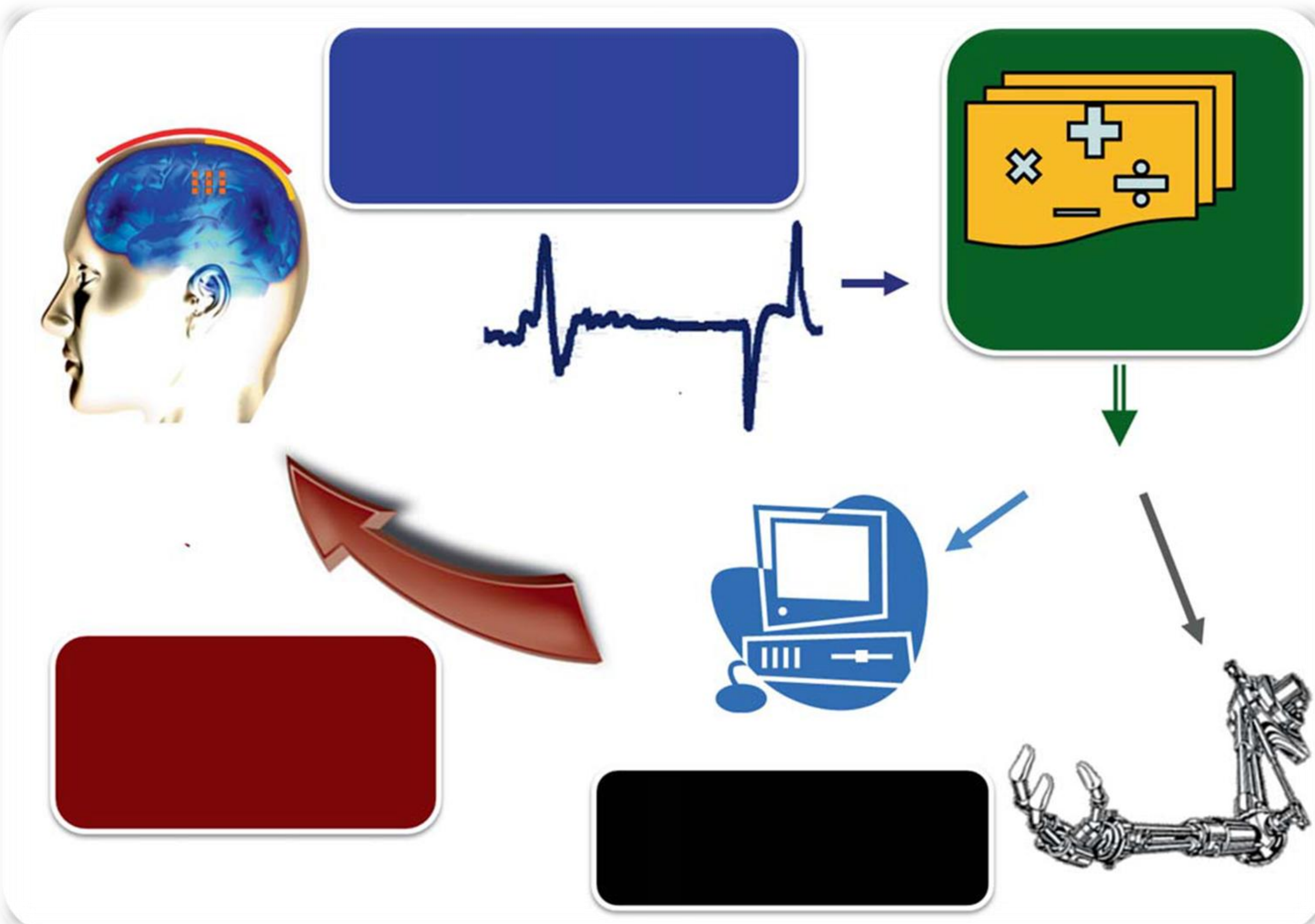
----professor *Chapin JK*

➡ BMI has moved at a stunning pace

Architecture of BMI

- Signal Acquisition
- Signal Processing
- Devices

Overview



Basic Techniques

- Three Dominant Tech
  - EEG(Electroencephalography)
  - ECoG(Electrocorticography)
  - Microelectrode Arrays

Basic Techniques - EEG

- Fast, noninvasive
- Low spatial resolution and SNR
- Two ways of application:
  - Asynchronous: detect the change
  - Synchronous: detect signals caused by stimuli

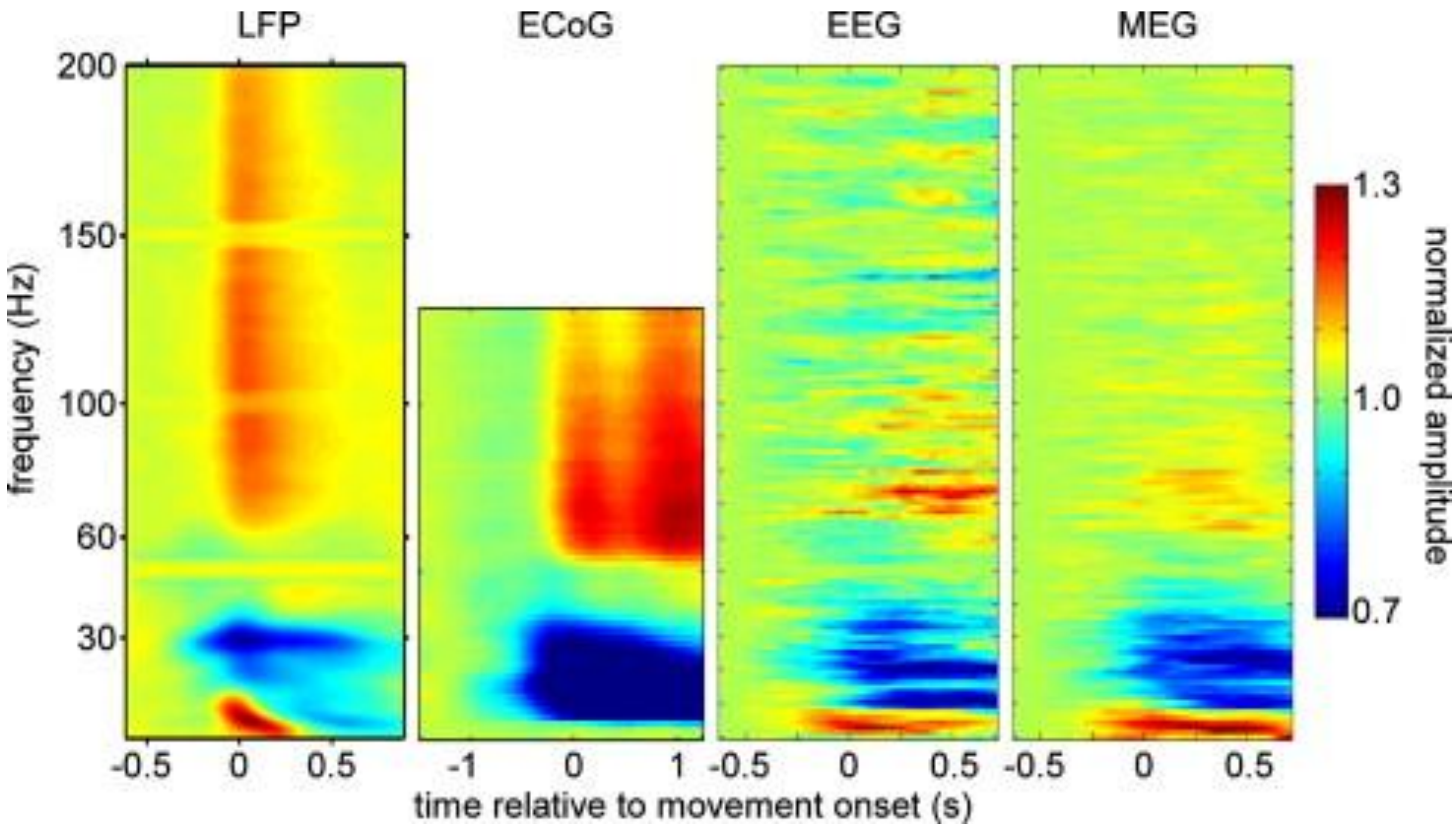
Basic Techniques - ECoG

- Higher resolution, broader bandwidth, higher characteristic amplitude, lower SNR
- Invasive and requires open skull
- Placed under the dura leads
- Also has asynchronous and synchronous applications

Basic Techniques - Microelectrode Arrays

- Collection from neural ensembles, high accuracy upon reconstruction of intended movements
- More invasive
- Implanted in frontoparietal areas
- In short term: the same cells are used by the decoder
- In long term: brain creates a layer of scar tissue around the electrodes, leading to a slow decrease of the SNR.

Comparison


LFP
ECoG
EEG
MEG
200
150
100
60
30
frequency (Hz)
-0.5
0
0.5
-1
0
1
-0.5
0
0.5
-0.5
0
0.5
time relative to movement onset (s)
1.3
1.0
0.7
normalized amplitude

Vector Algorithm

- Regression Model
  - Use behavioral variables, such as hand position or velocity, as a weighted linear combination of neuronal activity
  - To capture time-delayed dependencies between neural activity and movement that exist across different cortical areas.

Vector Algorithm

- Kalman Model
  - An explicit generative model of neural firing rate is used
  - least-square estimation
  - Dynamic

  - More sophisticated decoding scheme
    - Markov models
    - Bayesian inference approaches

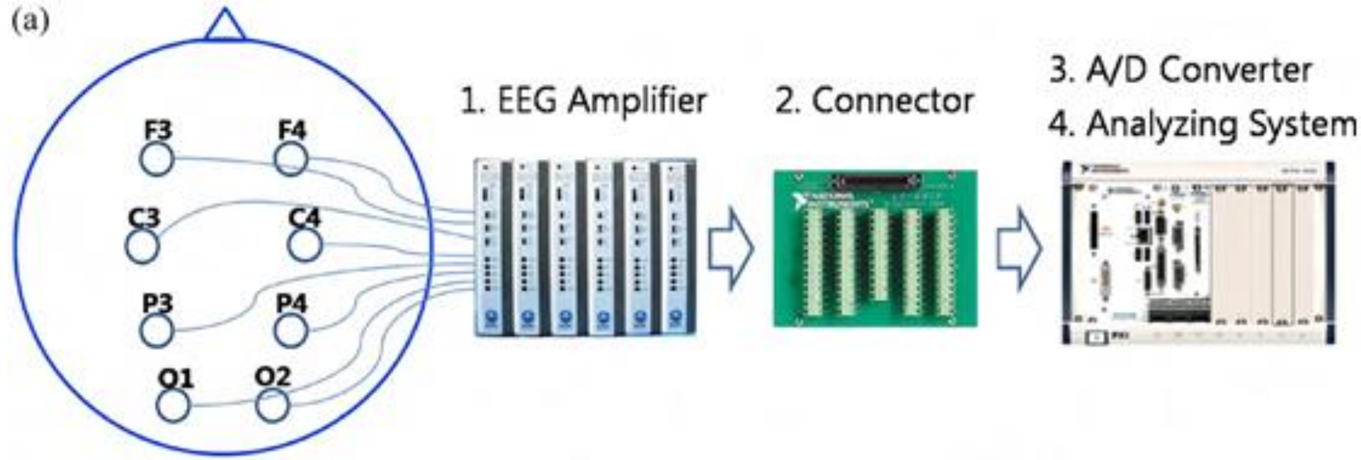
Feedback delivery

- Brain can adapt the firing rate of the recorded neurons and reduce the error in the control signal

Example of analyzing

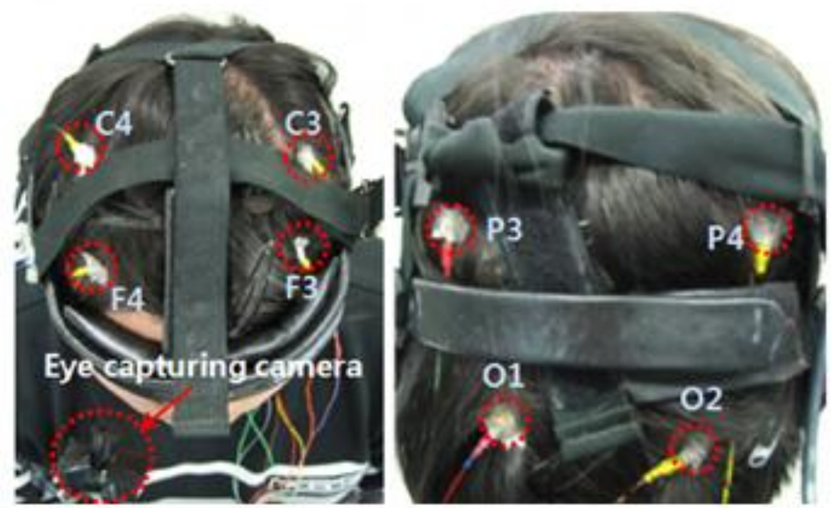
- From :interface method combined with eye tracking for 3D interaction

Example of analyzing



(b)

F3 F4 prefrontal cortex
C3 C4 lateral premotor cortex
P3 P4 posterior parietal cortex
O1 O2 occipital cortex

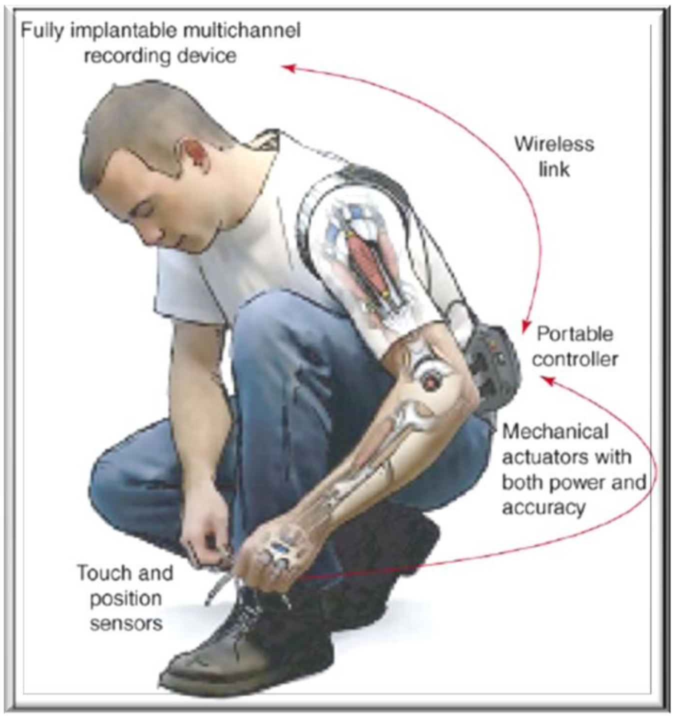


Applications of BMI

- Medical application
  - This technology helps paralyzed people to do things they may not achieve by themselves and helps them to communicate with the world.
- Others
  - Games or Devices based on brain waves

Examples

- Phosphene (virtual vision)
- Control of robotic arms



Examples


he first commercial Brain Computer Interface
y Mike Hanlon
1 Comment
7:30 February 21, 2008
9 Pictures
The first commercial Brain Computer Interface
Image Gallery (9 images)

Examples

Tim Sheridan, wearing a headset containing sensors for the forehead and earlobes to measure brainwave activity, uses his mind to raise a small purple foam ball as he demonstrates the Mindflex game at the Mattel display at the 2009 Consumer Electronics Show in Las Vegas, Nevada on January 8, 2009.

Sometimes people need to be trained to get accustomed to use BMI.

Videos

- Mind game
- Monkey controlling prosthesis

Problems

- interference from other electrical appliances
- signal's Imports of technology is inadequate
- side effects

Future work

- Obtaining stable, very long-term recordings (i.e. over years) of large populations of neurons (i.e. hundreds to thousands) from multiple brain areas
- Developing computationally efficient algorithms.
- Learning how to use brain plasticity to incorporate prosthetic devices into the body representation.
- Implementing a new generation of upper-limb prosthetics, capable of accepting brain-derived control signals to perform movements with multiple degrees of freedom.

References

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- [9]http://ppt.cc/_cQ~

February 22, 2008 The Computer-Human Interface has a new contender technology. Though we'd like to think we've come a long way with computers, the keyboard and mouse remain the predominant way we interface with them. We've had the unfulfilled promise of handwriting and voice recognition and hope that something better will come along sooner or later. Perhaps this is it - brain computer interface technology pioneer Emotiv Systems will have its EPOC neuroheadset to market before Christmas 2008. The lightweight US$300 EPOC is, worn on the head but does not restrict movement in any way as it is wireless. The set detects conscious thoughts, expressions and non-conscious emotions based on electrical signals around the brain. It opens up a plethora of new applications which can be controlled with our thoughts, expressions and emotions.
View all

The Emotiv EPOC will be the first high-fidelity brain computer interface (BCI) device for the video gaming market when it becomes available to consumers via Emotiv's Web site and through selected retailers in late 2008 for a recommended retail price of $299.
The company is also opening its Application Programming Interface (API) and providing a range of development tools to enable developers to integrate neurotechnology into their applications. The initiative will spur the adoption of brain computer interface technology in video gaming and other industries, enabling consumers to experience an entirely new form of human-machine interaction.
The Emotiv EPOC detects and processes human conscious thoughts and expressions and non-conscious emotions. By integrating the Emotiv EPOC into their games or other applications, developers can dramatically enhance interactivity, gameplay and player enjoyment by, for example, enabling characters to respond to a player's smile, laugh or frown; by adjusting the game dynamically in response to player emotions such as frustration or excitement; and enabling players to manipulate objects in a game or even make them disappear using the power of their thoughts.
Yet another direction enabled by the EPOC is that of live animation using the unit's facial recognition sensors to mimic the wearer's facial expressions in an animated avatar.
We look forward to exploring this one further. Very exciting possibilities.

Both Emotiv, which is based in San Francisco, and NeuroSky, of San Jose, think they have cracked these problems. Emotiv recently unveiled a prototype headset that has a mere 18 electrodes. Moreover, no gel is needed for these electrodes to make a good contact with the headset-wearer's scalp. Emotiv claims that its system can detect brain signals associated with facial expressions such as smiles and winks, different emotional states such as excitement and calmness, and even conscious thoughts such as the desire to move a particular object. It will not say precisely how this trick is done, but it seems to work well enough to make a virtual character in a game mimic a player's own facial expression, as well as permitting that player to move things around just by thinking about it.

To encourage others to add to this bag of tricks, Emotiv has also created a special kit for software developers. This should enable programmers to rewrite their code in a way that will allow Emotiv headsets to be plugged into existing applications. According to Nam Do, Emotiv's boss, those applications are most likely to be single-player computer games running on machines such as Microsoft's Xbox 360 and Sony's PlayStation 3. In the longer term, though, he thinks the system will be ideal for controlling avatars (the visual representations of players) in multiplayer virtual worlds such as Second Life.

For Stanley Yang, the boss of NeuroSky, even 18 sensors seems too clunky. His firm's technology has reduced the brainwave pickup to the minimum specification imaginable—a single electrode. Existing versions of this electrode are small enough to fit into a mobile phone and Mr Yang claims they will soon be shrunk to the size of a thumbnail, enabling people to wear them without noticing.

Reducing the mind-reader to this bare minimum makes it cheap—about $20, compared with several hundred for Emotiv's headset—though it is not as precise. But that lack of precision may not matter. According to Klaus-Robert Müller, a computer scientist at the Fraunhofer Institute in Berlin who has been studying the problem for years, a single well-placed electrode is sufficient to gather meaningful information from brain waves. On the other hand, Dr Müller and his team have been unable, as yet, to produce a device that works well outside the cosseted environment of a laboratory.

There are several reasons for this. First, although human brains are similar to one another in general, they are different in detail, so a mass-produced headset with the electrodes in standard locations may not work for everyone. Second, about one-third of the population is considered “illiterate”, meaning in this context that not even a full-fledged medical EEG can convert their brain activities into actions. Third, electrical signals generated by muscular activity such as blinking are easily confused with actual brain-wave readings. Wink at a fellow player at the wrong moment, then, and you might end up dropping that sarsen you have lifted so triumphantly from the fields of Salisbury Plain on the toes of your avatar's foot.

Obtaining stable, very long-term recordings (i.e. over years) of large populations of neurons (i.e. hundreds to thousands) from multiple brain areas. This task encourages development of a new generation of biocompatible 3D electrode matrices that yield thousands of channels of recordings while producing little tissue damage at implantation and minimal inflammatory reaction thereafter.

Developing computationally efficient algorithms, that can be incorporated into the BMI software, for translating neuronal activity into high-precision command signals capable of controlling an artificial actuator that has multiple degrees of freedom.

Learning how to use brain plasticity to incorporate prosthetic devices into the body representation. This will make the prosthetic feel like the subject's own limb.

Implementing a new generation of upper-limb prosthetics, capable of accepting brain-derived control signals to perform movements with multiple degrees of freedom.

We now discuss some potential avenues for addressing