

# CSE 490i: Design in Neurobotics

Yoky Matsuoka (instructor)

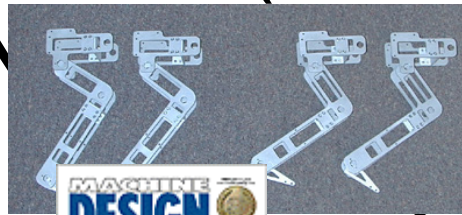
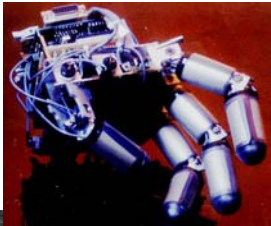
Lecture: TTH 10:30-11:20 EEB 003

Labs: TTH 11:30-1:20 CSE 003E

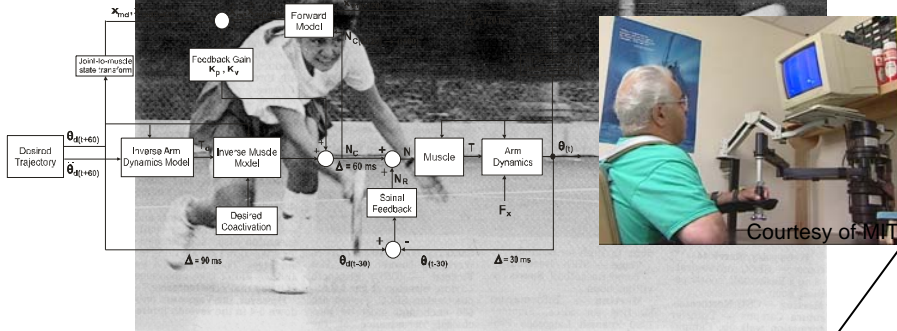
# Who (the hell) is Yuuka?



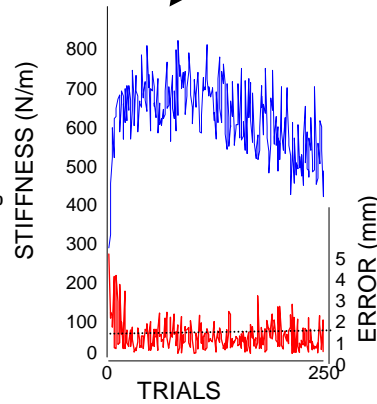
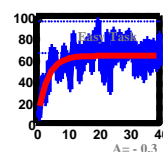
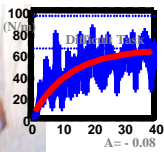
2000 Guinness World Record  
Most Intelligent Robot



2000 Guinness World Record  
Most Advanced Robot



U.S. patent #5,755,645



- 1993 B.S. EECS, UC Berkeley
- 1995 S.M. EECS, MIT
- 1998 Ph.D. EECS, MIT
  - In Computational Neuroscience
- 1998 -1998 postdoc, MIT
  - Brain and Cognitive Sciences
- 1998 - 2000 postdoc, Harvard
  - Division of Engr. and Applied Sci.
- 2001 - 2006 Assistant Prof., CMU
  - Robotics Institute
  - Mechanical Engineering
  - Biomedical Engineering
  - Center for the Neural Basis of Cognition

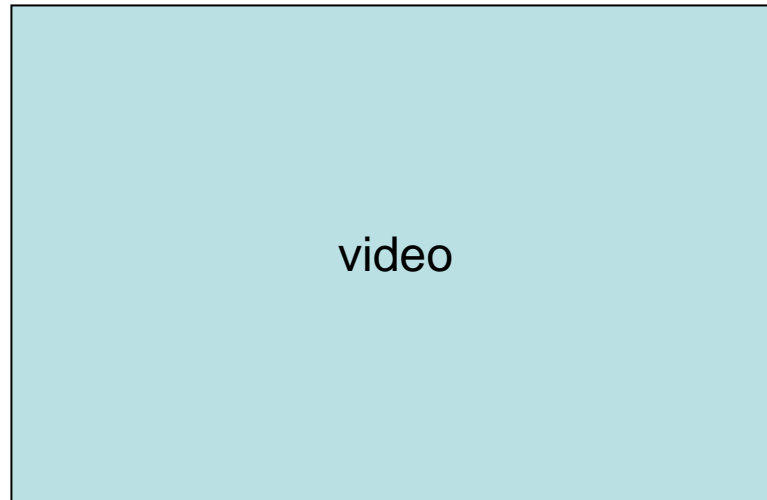


# What is Neurobotics?

- Lies at the intersection of robotics and medicine.
- Aims to build a robot-human closed loop system to alter the neural control of movement as a way to rehabilitate, assist, and enhance human motor control and learning capabilities.
- Typically, the primary target population is individuals with strokes, spinal cord injuries, traumatic brain injuries, and other injuries that inhibit daily activities.
- However, it could also target sports medicine, military, and entertainment applications.

# First human trial of brain-computer interface

From Cyberkinetics, Inc.



## Ideas:

- Implanted electrodes on the brain (cortical) surface
- Wired to a local amplifier (yellow box) then connected to the computer
- Computer processes the neuronal data and statistically correlate the signals with

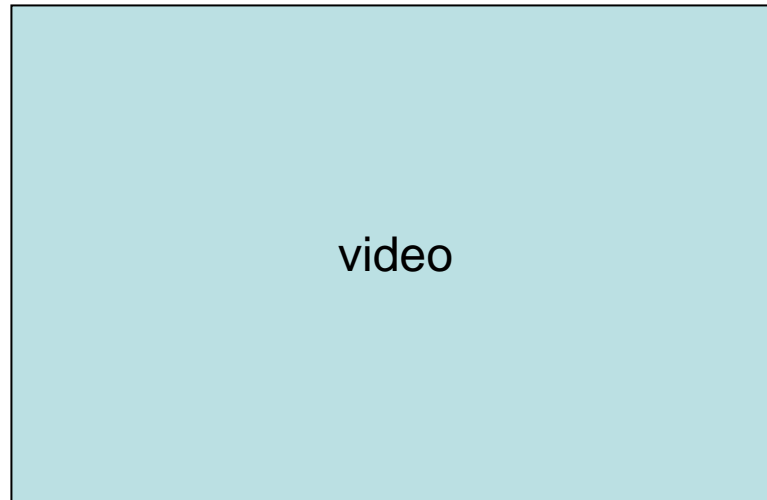
patient thinks left and right = cursor moves left and right

patient thinks up and down = cursor moves up and down

(often patients are told to think of balloon floating up and down)

## First human trial of nerve reinnervation bionic arm

<http://www.ric.org/bionic/>



### Ideas:

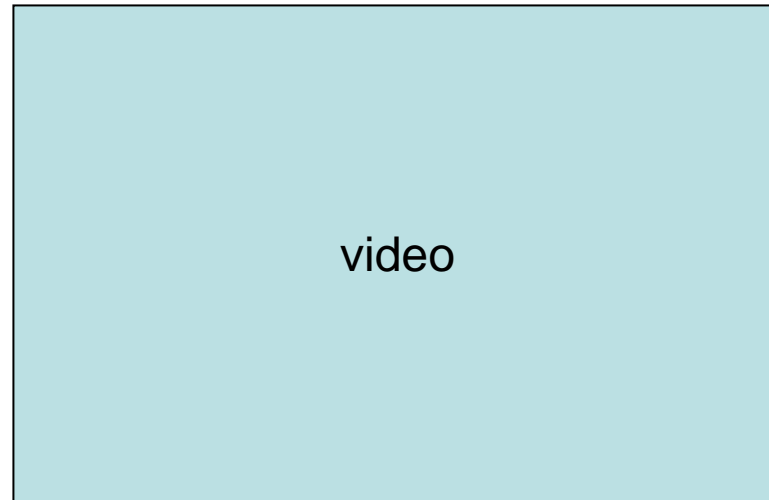
- surgeon rewired some of his shoulder nerves to the chest muscles
- tap into the chest muscle activity with electromyography
- map the signals to the robotic arm joints (as naturally as possible)
- Jesse thinks about naturally moving his original arm to move the joints.

# So is this research done?

- Unfortunately, no. They are the first brave human trial efforts but still need A LOT of work before using it clinically.
  - Cyberkinetics has had 2 patients so far: the training didn't go well for one patient and asked to have the system removed.
  - The system is time consuming to train.
  - Jesse has been in an intensive rehabilitation for months and he has just gotten to the point where he can do a bang-bang control of joints (no stopping in the middle).
  - Jesse would rather use his own non-articulated prosthetic arm most of the time.
  - Still infection is a big problem.
  - ... most research in this area of work is with animals because it is still experimental and the technique is not perfected.

# First 3D robotic arm control by monkey brain

Courtesy of Dr. Schwartz, Univ. of Pittsburgh



Chauncey

## Ideas:

- Chronic array of electrodes are implanted in the brain area that controls the arm
- The neuronal activities were recorded until their own arm movement direction and the neuronal activities are correlated.
- Strapped the arm down and use the same signals to control the robotic joints.

Problem? We cannot do this for humans because we cannot predict an injury!  
Must understand the brain encoding structure and mechanisms!

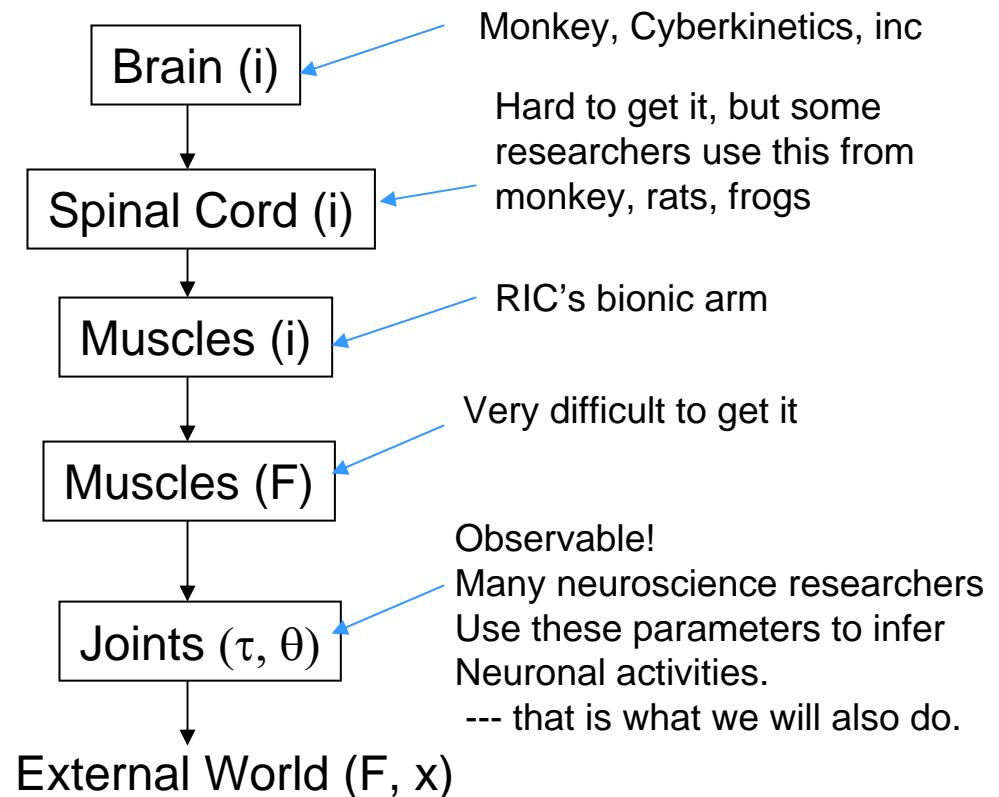
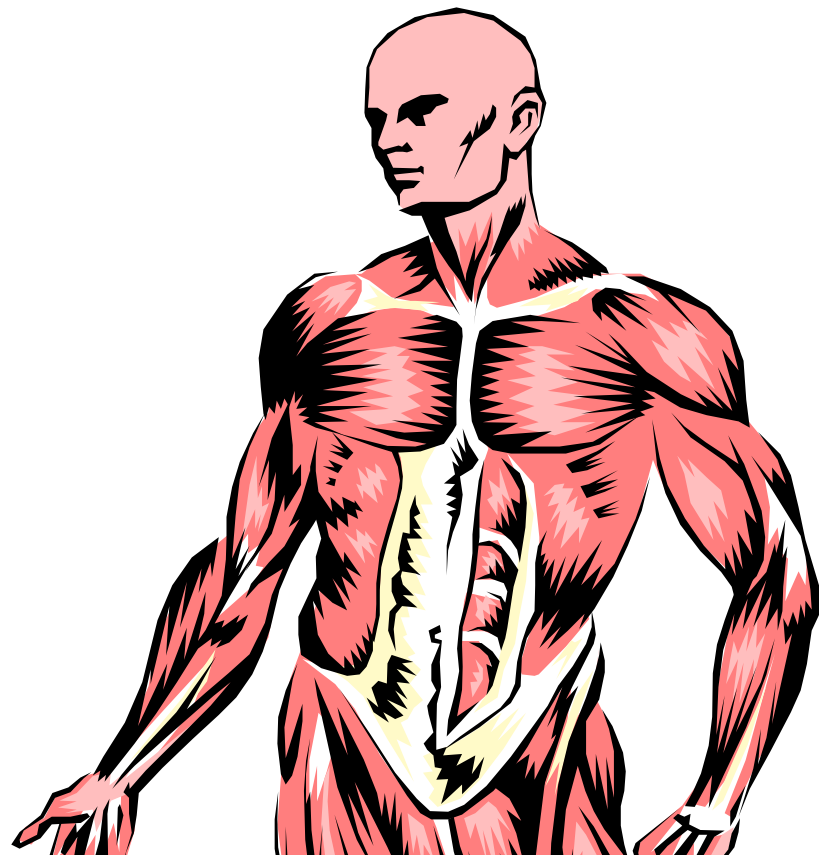
# So that leads us to this course

- This course is an introductory design course in Neurobotics
- Focus: learning human neural control of movement, using physiological signals as inputs, and controlling a mechanical device.
- You will learn: simple control laws, hands on experience and programming in controlling robots, and applying knowledge of human movements to move the robot.
- There is a design project competition at the end of the quarter.

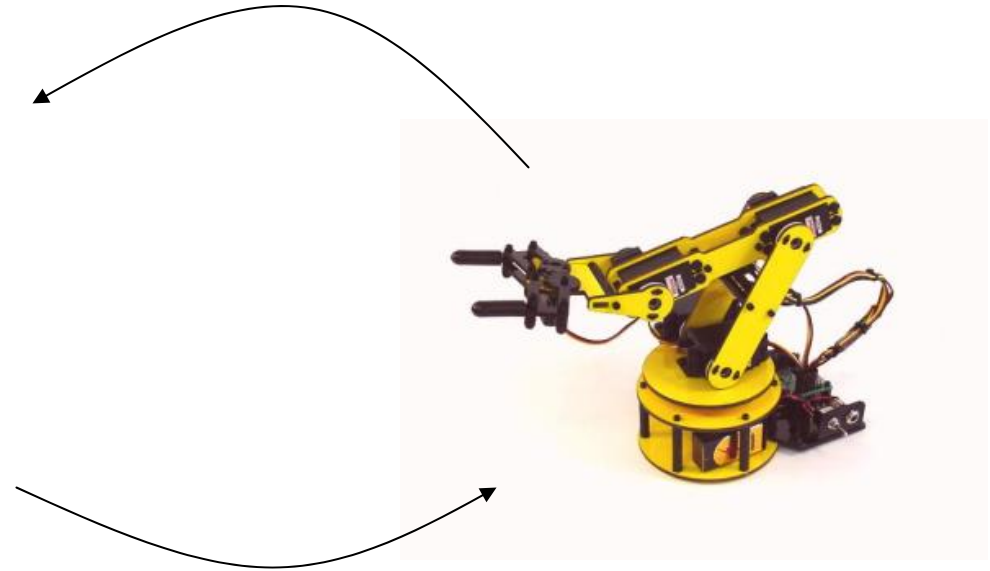


# It is hard to tap into the neuronal/brain signals for the course

- Can't be invasive.
- Time consuming to set things up.
- There are other ways to tap into the neuronal information:



# Our Neurobotics Setup



Actually, this type of relationship has been studied in the neuroscience literature  
As a step toward neurobotics and brain-machine interface effort.  
(you will read a paper in your first assignment)

# Handouts

- Course Syllabus
- Course Guideline
- Problem Set 1
- Two journal papers (online)
  
- Don't forget to sign in on the signup sheet!
  - If you don't sign up, you will not get a lab slot