



ME 328: Medical Robotics
Winter 2019

Lecture 4: Cooperative manipulation

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What's Next

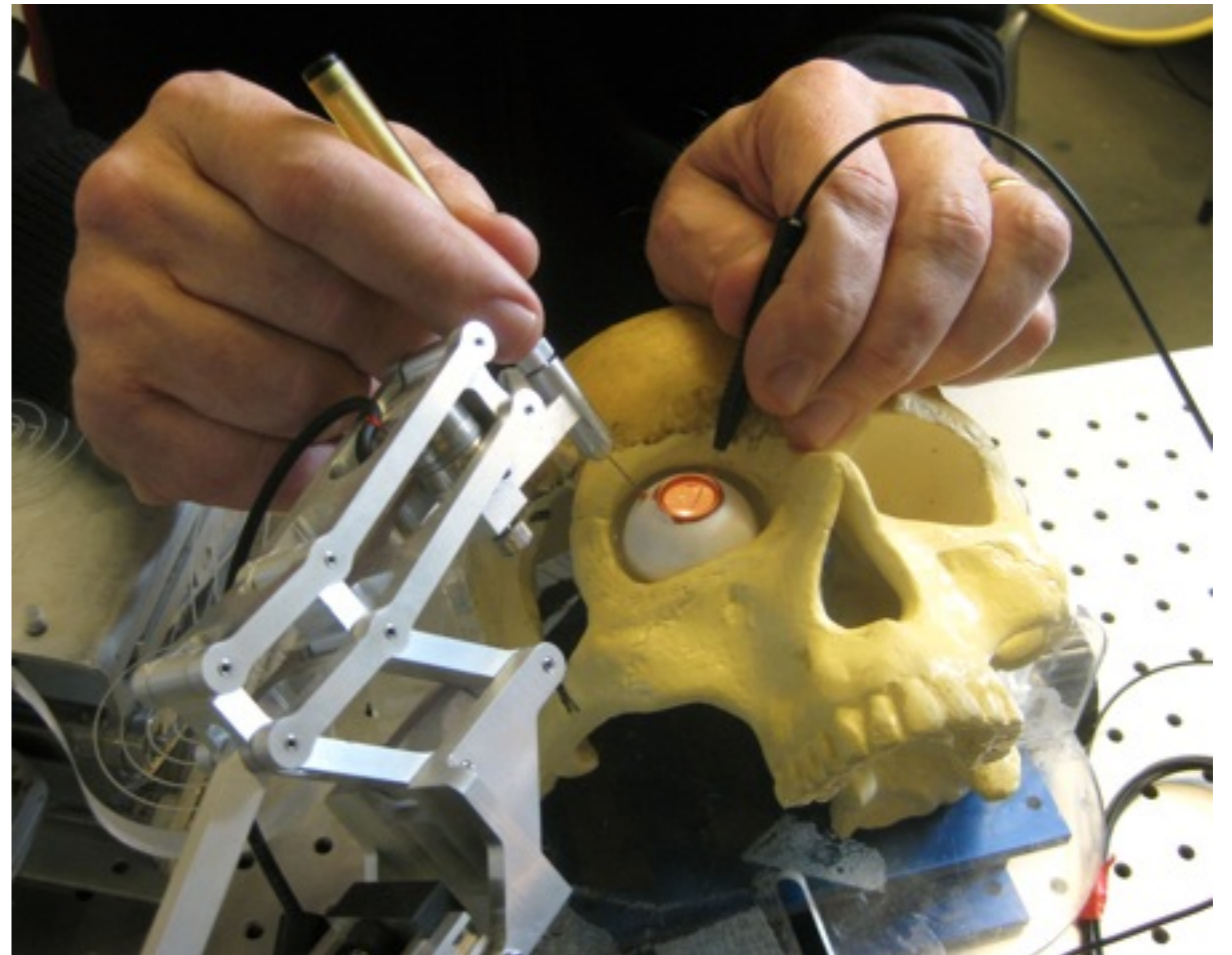
- Assignment 1 due today at 4 pm
- Assignment 2 will be posted today (see lab introduction handout also)
- Catherine Mohr this Friday
- Sherry Wren Friday next week **(at 8:30 am!)**
- Lab Tours scheduled for....

Cooperative Manipulation

so-called “steady-hand” robots



Mako's RIO Robotic Arm
Interactive Orthopedic System



JHU Eye Surgery Robot

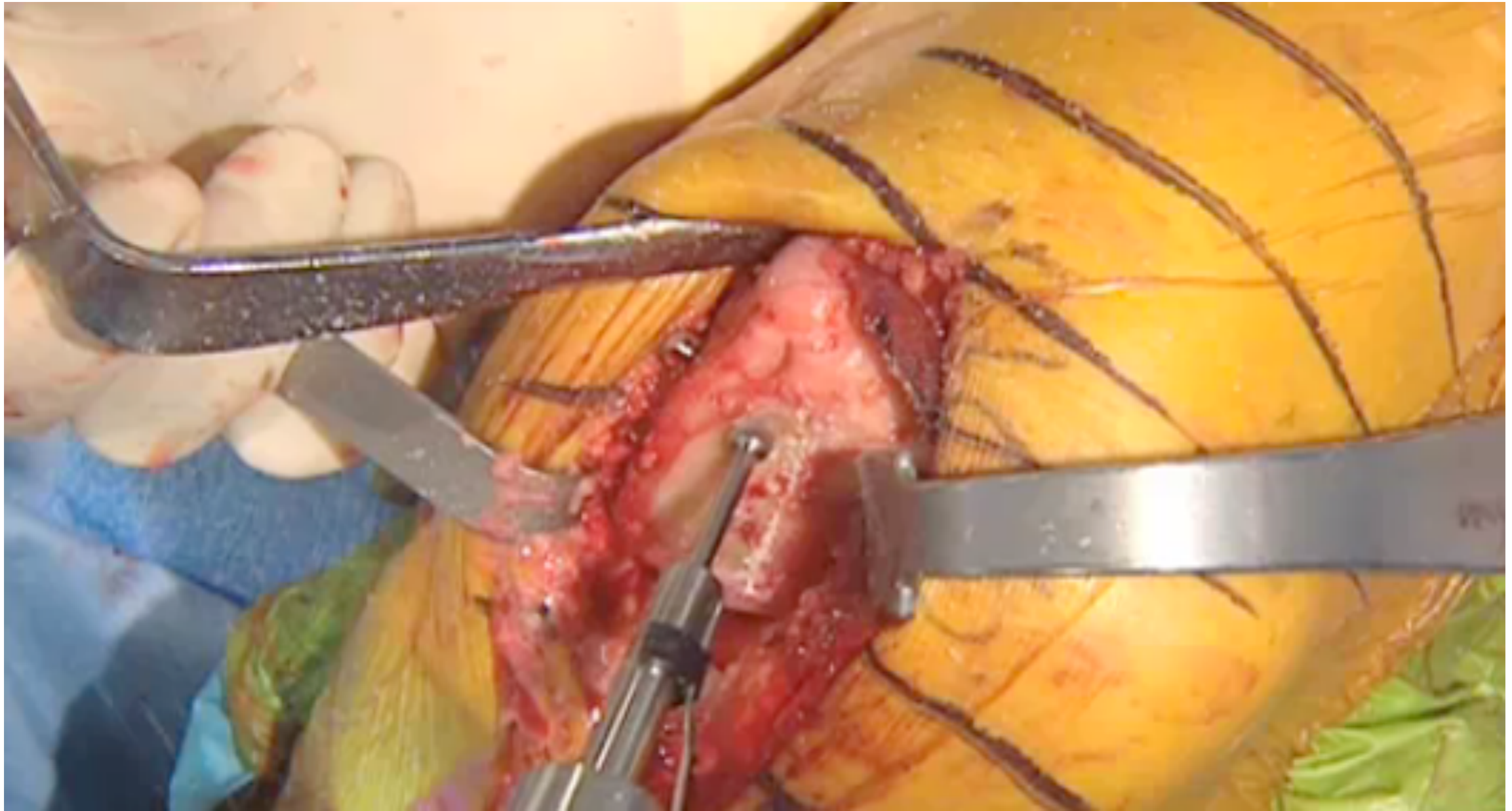
steady-hand robot behavior



Johns Hopkins
Steady Hand Robot

with RCM: <http://www.youtube.com/watch?v=qQEJEM7YeXY>

MAKO Surgical Robot (makoplasty)



<http://www.youtube.com/watch?v=Wun4AjcFZSw>

Barrett WAM Arm



The WAM and associated technologies are the basis for the MAKO surgical robot

**Robodoc is a
similar system
(with much
more history)**

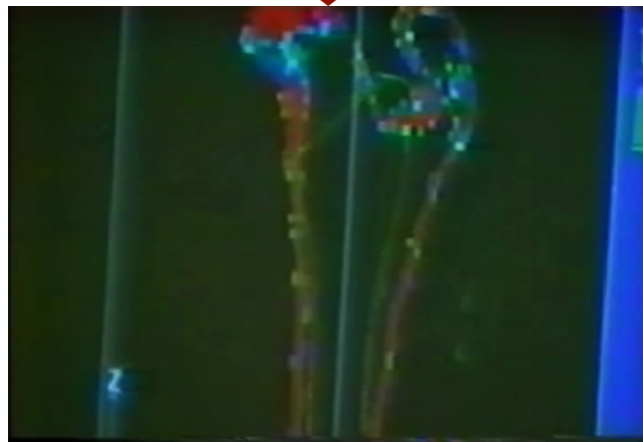


http://robodoc.com/patient_about_history.html

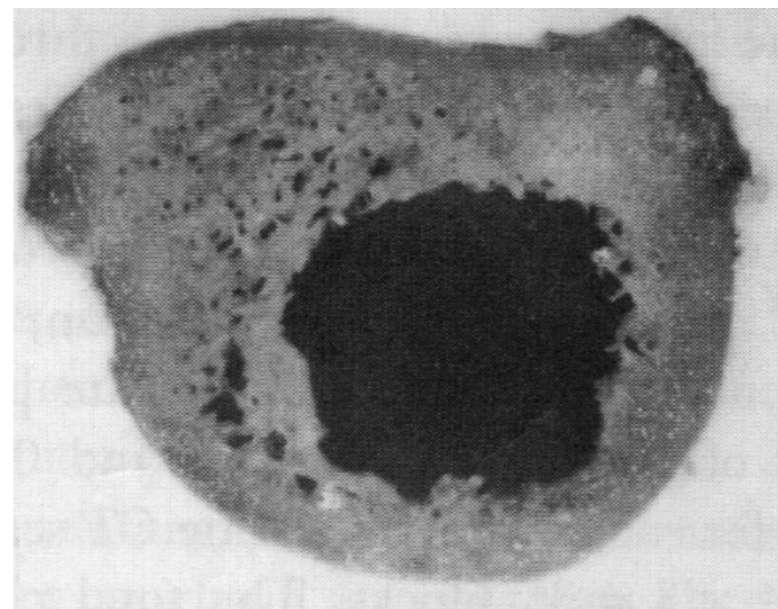
a more “intelligent” surgical system than pure teleoperation



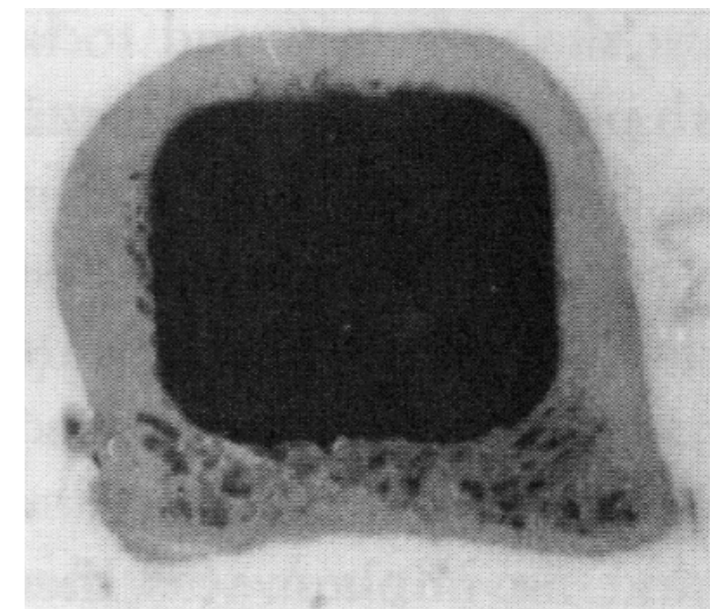
close integration with information systems



more active user assistance



Manual Surgery



Robotic Surgery

admittance control

the user's applied force is measured, and the robot is controlled to move proportionally to that force

a typical implementation is:

$$\dot{x}_d = k_a f$$

$$f_a = k_p(x_d - x) + k_d(\dot{x}_d - \dot{x})$$

x_d, \dot{x}_d desired robot position, velocity

f_a actuator force

k_a admittance gain

x, \dot{x} robot position, velocity

f force applied by the user (measured)

k_p, k_d proportional and derivative gains

note: not all cooperative manipulators use admittance control, but many do...

questions

- what happens when k_a is zero?
- how would you create a virtual surface/wall using admittance control?

admittance control

enables very slow, steady motions

is an excellent underlying control structure for applying “virtual fixtures” to guide motions

can be applied to teleoperators as well as cooperative manipulators

for cooperative manipulation,
it is best used on a very accurate,
non-backdrivable robot

impedance

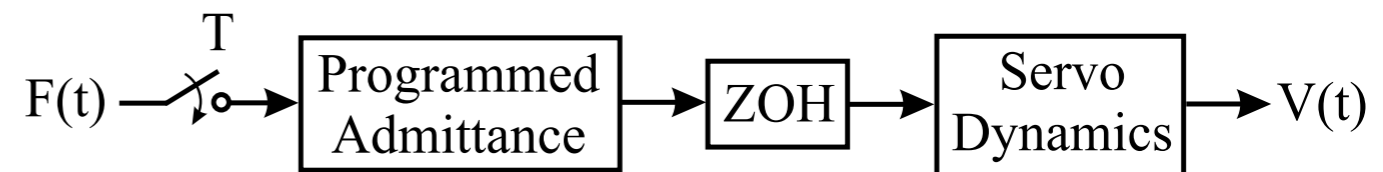
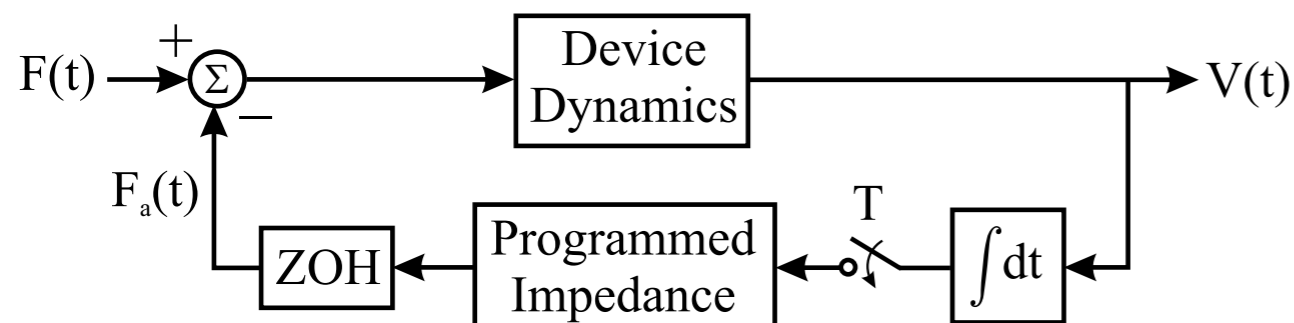
admittance

$$F(s) = Z(s)X(s)$$

$$X(s) = Y(s)F(s)$$

dual concepts, just different causality

with implications for practical
implementation on robots



questions

- what are some advantages and disadvantages of cooperative manipulation as compared to teleoperation?
- what are some advantages and disadvantages of admittance control as compared to impedance control?

Assignment 2

Problem 0: Commentary on seminar

Problem 1: Read/skim papers, answer questions

Problem 2: Implement teleoperators and review performance data

Problem 3: Implement admittance control and review performance data

Due Wednesday Jan. 23 at 4 pm

Lab Introduction

- proper handling of the Phantom Omni robot/haptic devices
- use of the programs you need to test the Omni setup
- opening, modifying, and compiling the template program for writing and testing Omni control laws
- the details of the template program you'll be working with
- how to interpret the experimental data you save