

Haptic Systems

530-655

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Lecture 5

13/1/06

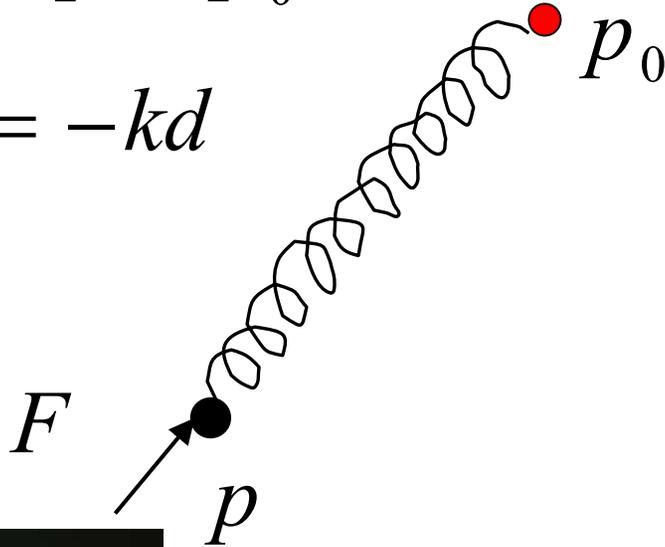
Introduction to teleoperation and force-feedback cooperative environments

- A review of the last lectures (virtual spring)
- Connecting two haptic devices by a virtual spring
- A position-position teleoperation structure
- Control design objectives
- Network model of a teleoperation system
- Cooperative manipulation
- References

A review of the last lectures (virtual spring)

$$d = p - p_0$$

$$F = -kd$$



A virtual spring

```
inialization()
```

```
while(1){
```

```
p = tipPosition(theta_1, theta_2, theta_3)
```

```
//Virtual spring
```

```
p_0 = {0,0,0}
```

```
d = p - p_0
```

```
F = -kd
```

```
tau = J^T F
```

```
I_i = tau_i / k_i
```

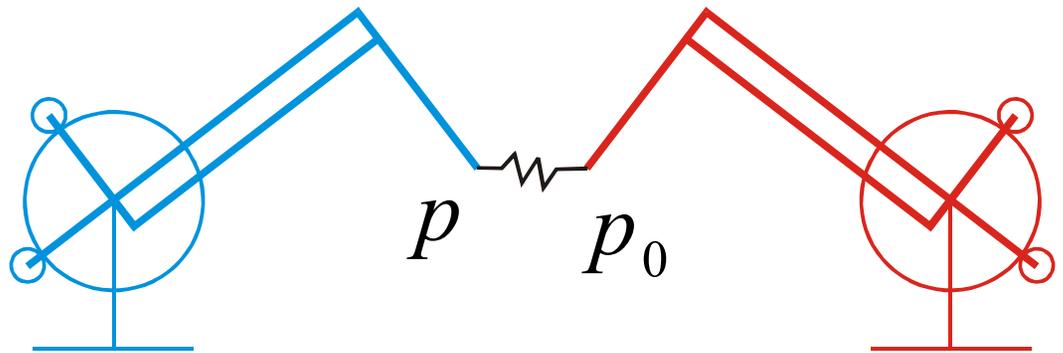
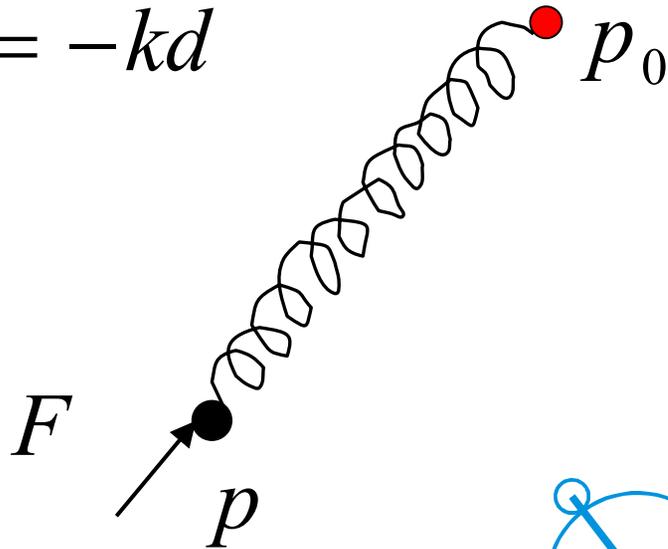
```
rtTaskWaitAPeriod()}_3
```

Connecting two haptic devices by a virtual spring

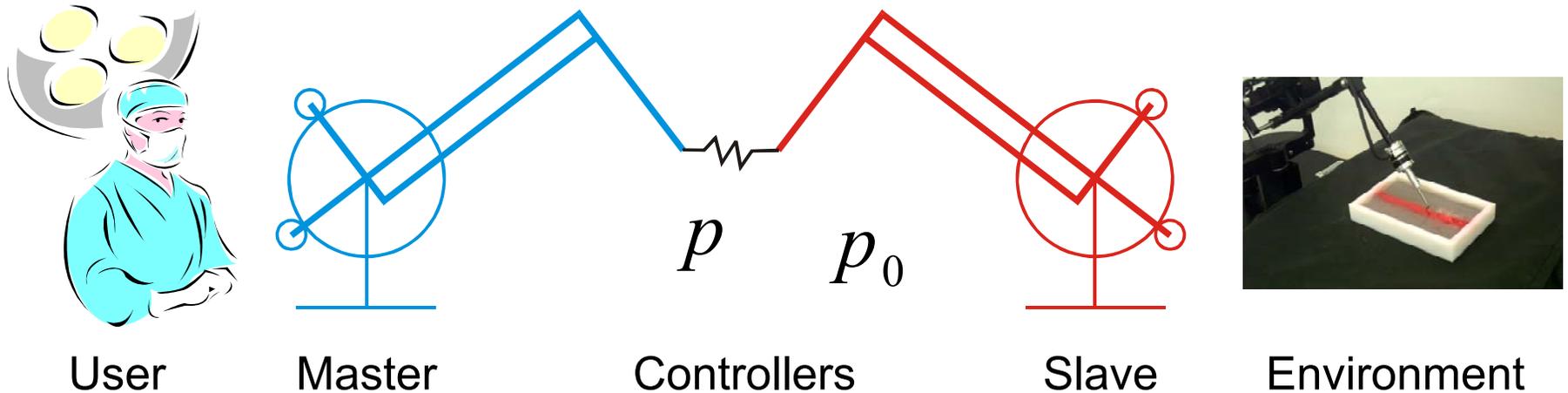


$$d = p - p_0$$

$$F = -kd$$



A position-position teleoperation structure



Objectives:

- Performance (Telepresence)
The users should feel that they are directly performing a task rather than controlling a robot
- Stability
Force feedback makes the problem of providing stability more difficult

Control problems: delay, friction, device mass

Pseudo code for a position-position Teleoperation

inialization()

while(1){

$$p_m = \text{masterTipPosition}(\theta_{m1}, \theta_{m2}, \theta_{m3})$$

$$p_s = \text{masterTipPosition}(\theta_{s1}, \theta_{s2}, \theta_{s3})$$

$$d = p_m - p_s$$

$$F_m = -kd$$

$$F_s = kd$$

$$\tau_m = J_m^T F_m$$

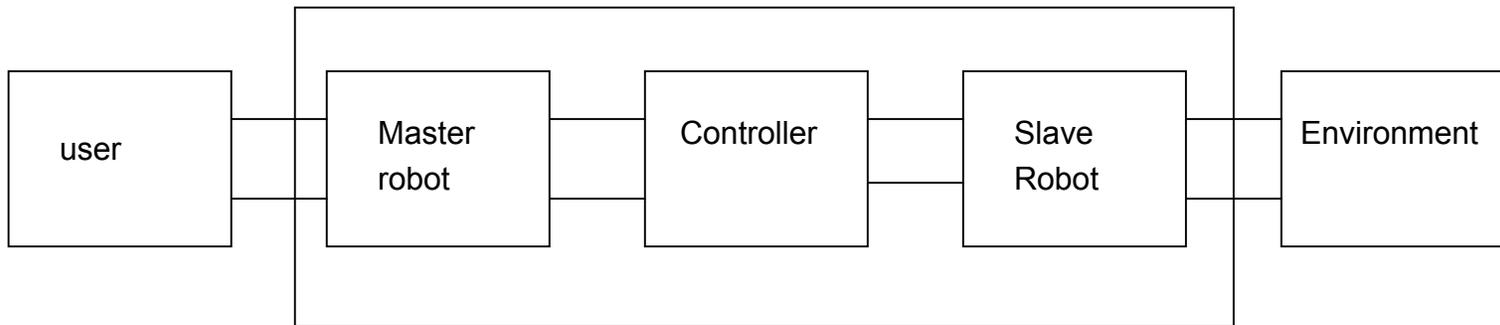
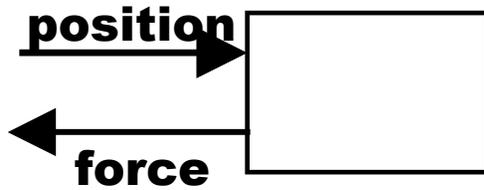
$$\tau_s = J_s^T F_s$$

$$I_{mi} = \frac{\tau_{mi}}{k_{si}}$$

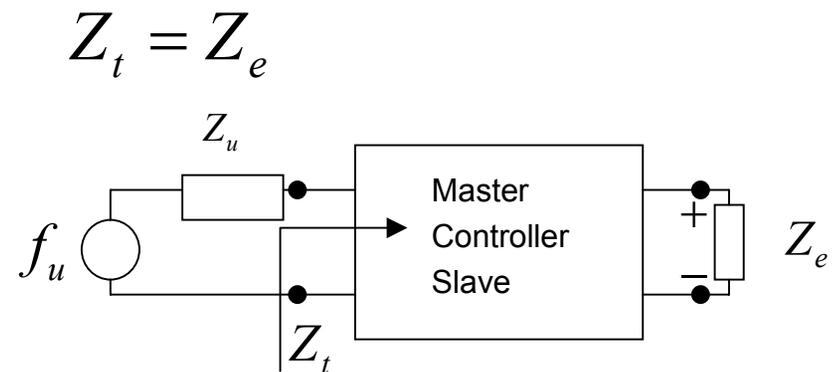
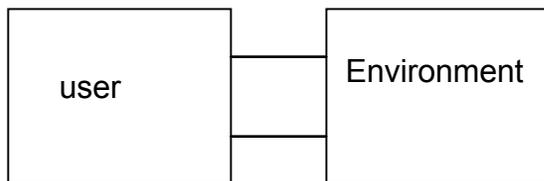
$$I_{si} = \frac{k_{mi}}{\tau_{si}}$$

rtTaskWaitAPeriod() }

Network Model of a Telemanipulation system



Transparency



$$Z_t = Z_e$$

da Vinci system

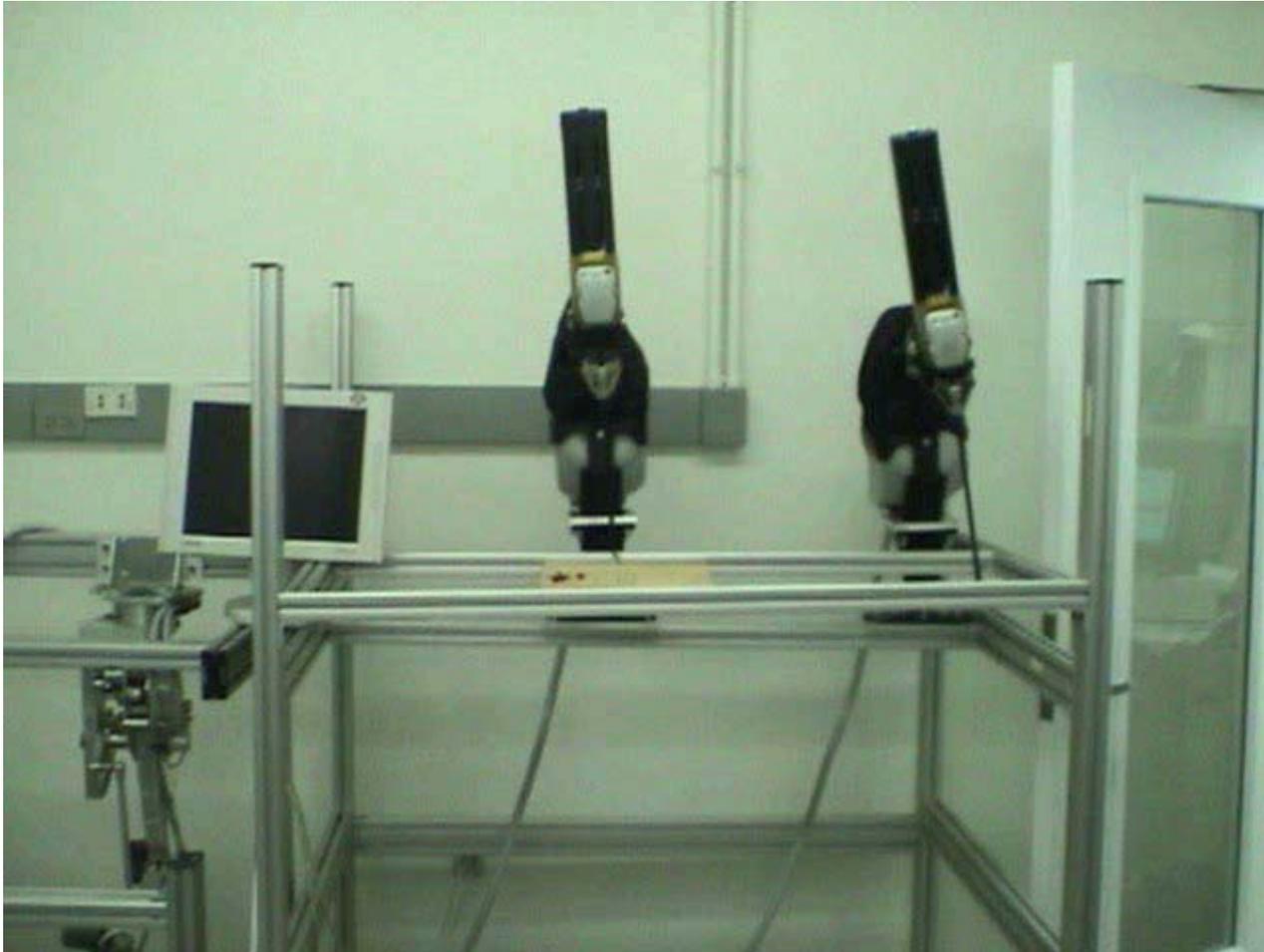


Master Tele Manipulators



Patient Side Manipulators

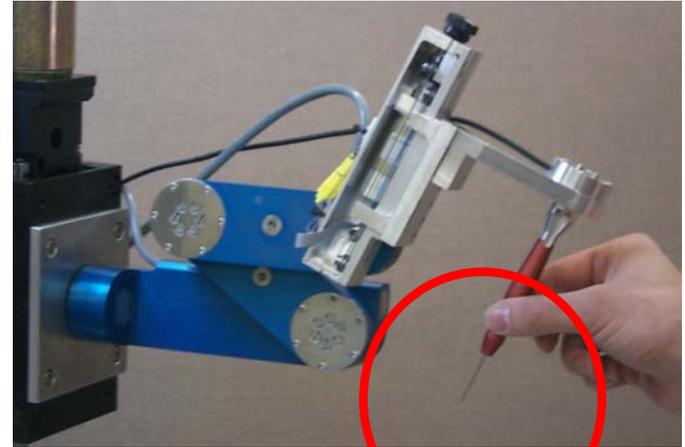
A video of da Vinci system



Video demonstration of telemanipulation control, and dexterous manipulation

Cooperative manipulation

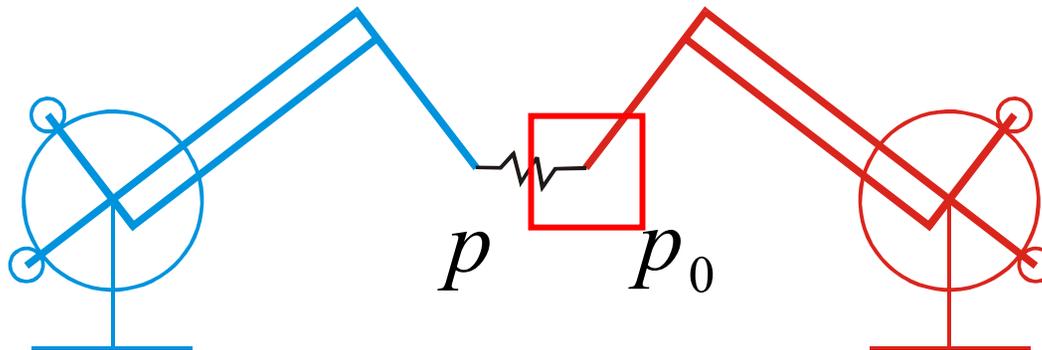
force applied to the tip = environment
force + virtual sphere force



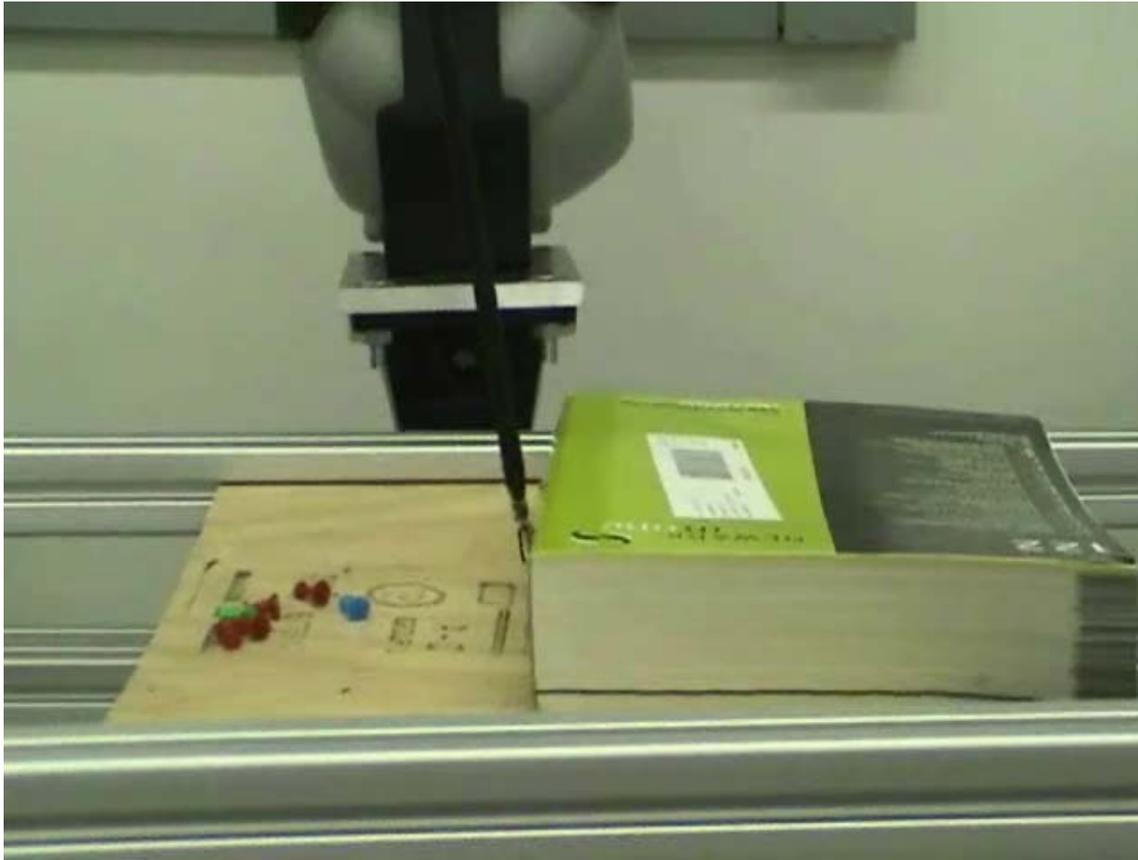
A virtual sphere ←

Virtual fixture

Adding a virtual environment to the master or slave side to prevent the user restricted areas



A video of virtual fixture



Demonstration of virtual fixture

References

Sheridan, T.B. (1992), Telerobotics, Automation, and Human Supervisory Control, MIT Press, Cambridge, MA.

A. M. Okamura, "Methods for Haptic Feedback in Teleoperated Robot-Assisted Surgery," *Industrial Robot*, Vol. 31, No. 6., pp. 499-508, 2004

Next Week

No class on Monday

Haptic rendering of contact with 3D rigid and deformable objects