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

\[
\text{A virtual spring}
\]

\[
\text{initialization()}
\]

\[
\text{while(1)}\
\]

\[
p = \text{tipPosition}(\theta_1, \theta_2, \theta_3)
\]

//Virtual spring

\[
p_0 = \{0, 0, 0\}
\]

\[
d = p - p_0
\]

\[
F = -kd
\]

\[
\tau = J^T F
\]

\[
I_i = \frac{\tau_i}{k_i}
\]

\[
\text{rtTaskWaitAPeriod()}\}
\]
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

\begin{Verbatim}
initialization()
while(1) {
    p_m = masterTipPosition(\theta_{m1}, \theta_{m2}, \theta_{m3})
    p_s = 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_{mi}}
    I_{si} = \frac{\tau_{mi}}{k_{si}}
    rtTaskWaitAPeriod()
}
\end{Verbatim}
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

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


Next Week

No class on Monday
Haptic rendering of contact with 3D rigid and deformable objects