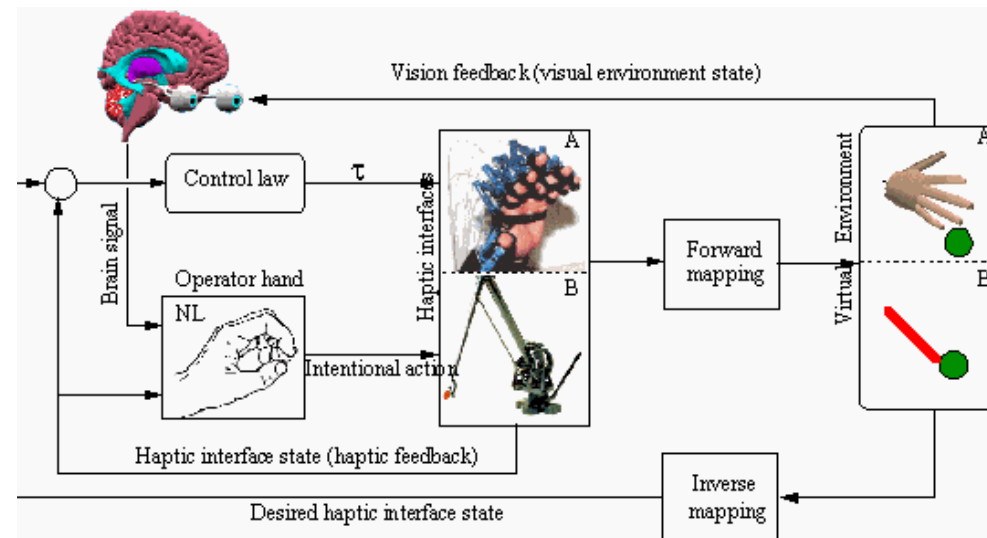
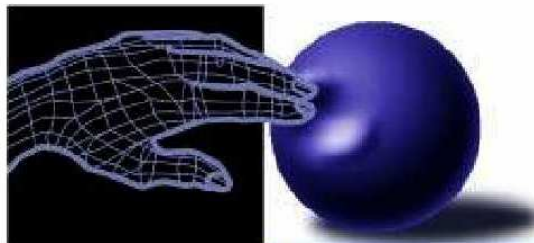


Development of haptic device for Minimally Invasive Surgery Simulation using pneumatic actuator



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Development of haptic interface with 1 DOF



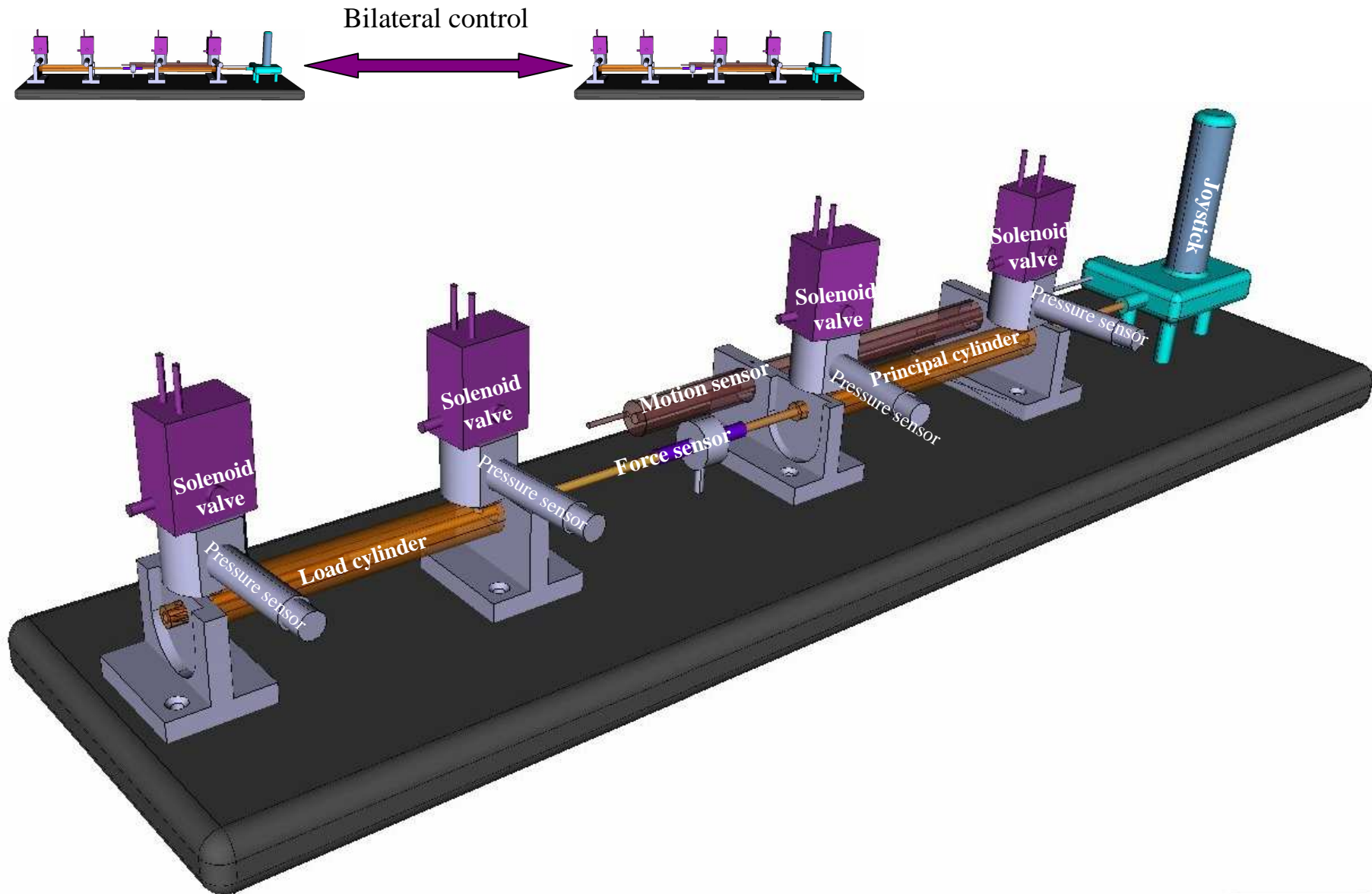
Principle



Specifications

Degree of freedom (DOF)	1
Maximum exertable force	50 N
Nominal Force resolution	0.1 N
Workspace	100 mm
Nominal position resolution	0.1 mm
Life span	> 1 million cycles

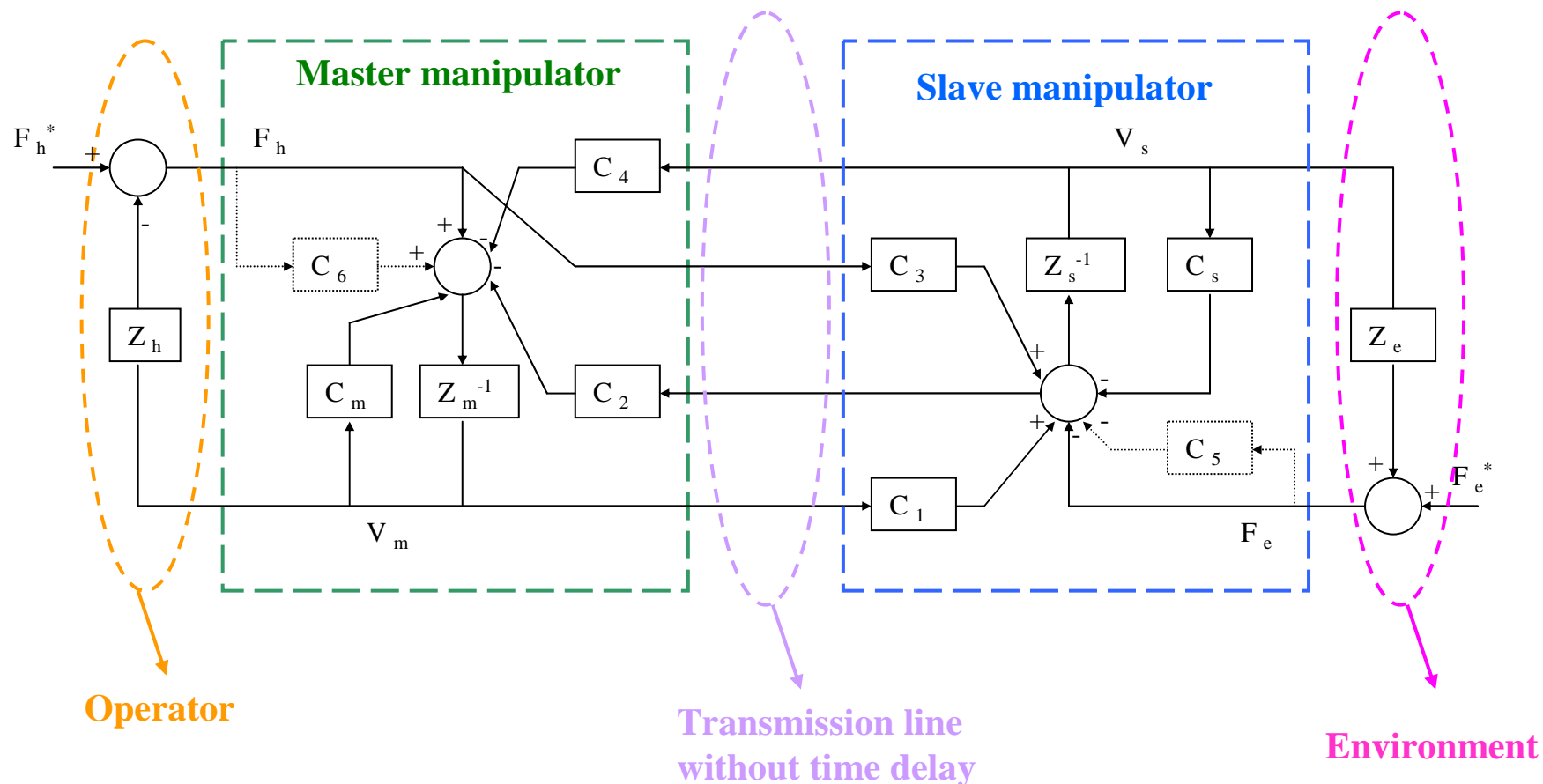
Developed manipulators



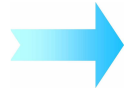
Bilateral control in teleoperation



Diagram of 4 channels [Lawrence 1993]



Possibility to develop other architectures like diagram of 2 channels or 3 channels, in order to reduce the number of the sensors



Nonlinear model of pneumatic cylinder :

$$\frac{dx}{dt} = v \quad (1)$$

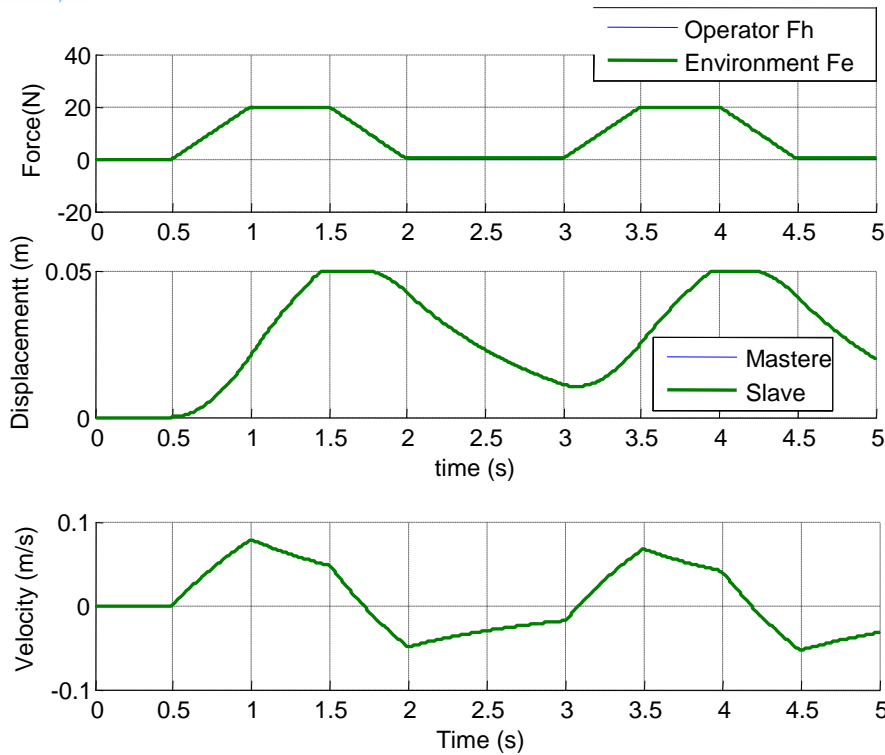
$$\frac{dv}{dt} = \frac{1}{M} (S_p P_p - S_n P_n - bv - F_{ext}) \quad (2)$$

$$\frac{dP_p}{dt} = \frac{krT}{V_p(x)} \left(q_m(U, P_p) - \frac{S_p}{rT} S_p v \right) \quad (3)$$

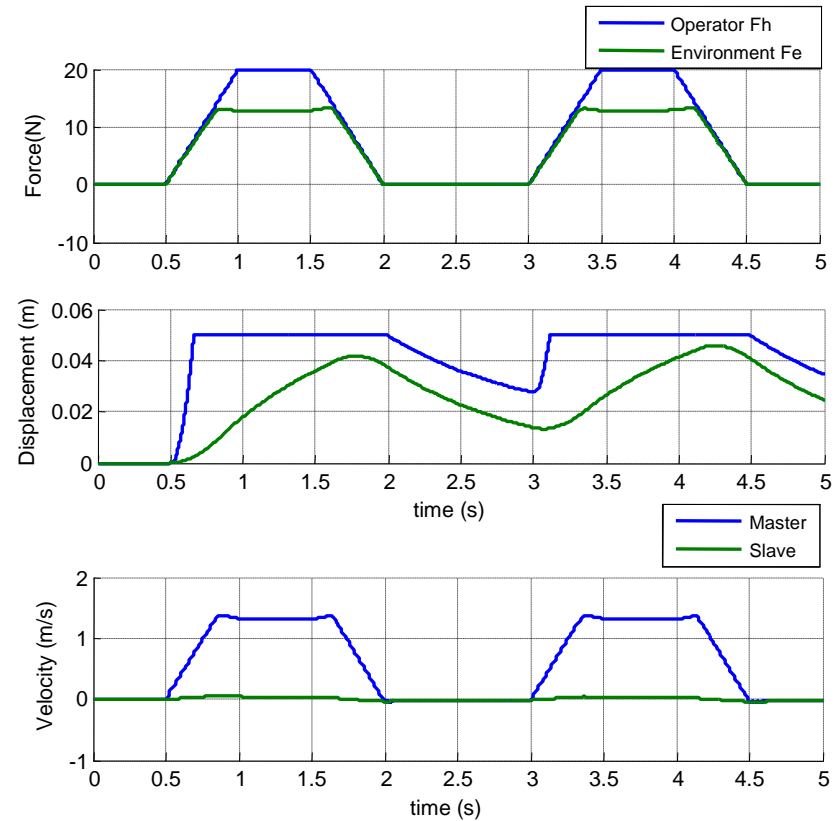
$$\frac{dP_n}{dt} = \frac{krT}{V_n(x)} \left(q_m(U, P_n) - \frac{S_n}{rT} S_n v \right) \quad (4)$$



Force and motion of the master, slave



4 Channel diagram



2 Channel diagram position-position



Future works

- Validation of the bilateral control by experiment
- Development of the bilateral control on a 3 DOF pneumatic interface
- Test the viability of learning principle using the simulator