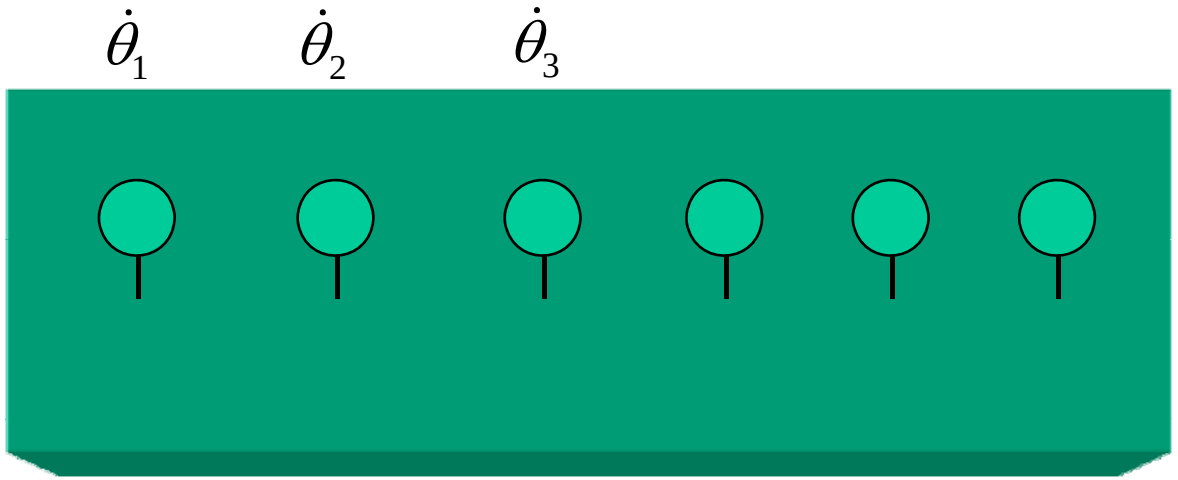
Kinematics of Teleoperation

1. Joint rate control
2. Resolved rate control
3. Master slave control
4. Generalized master slave

Joint Rate Control



Control Panel

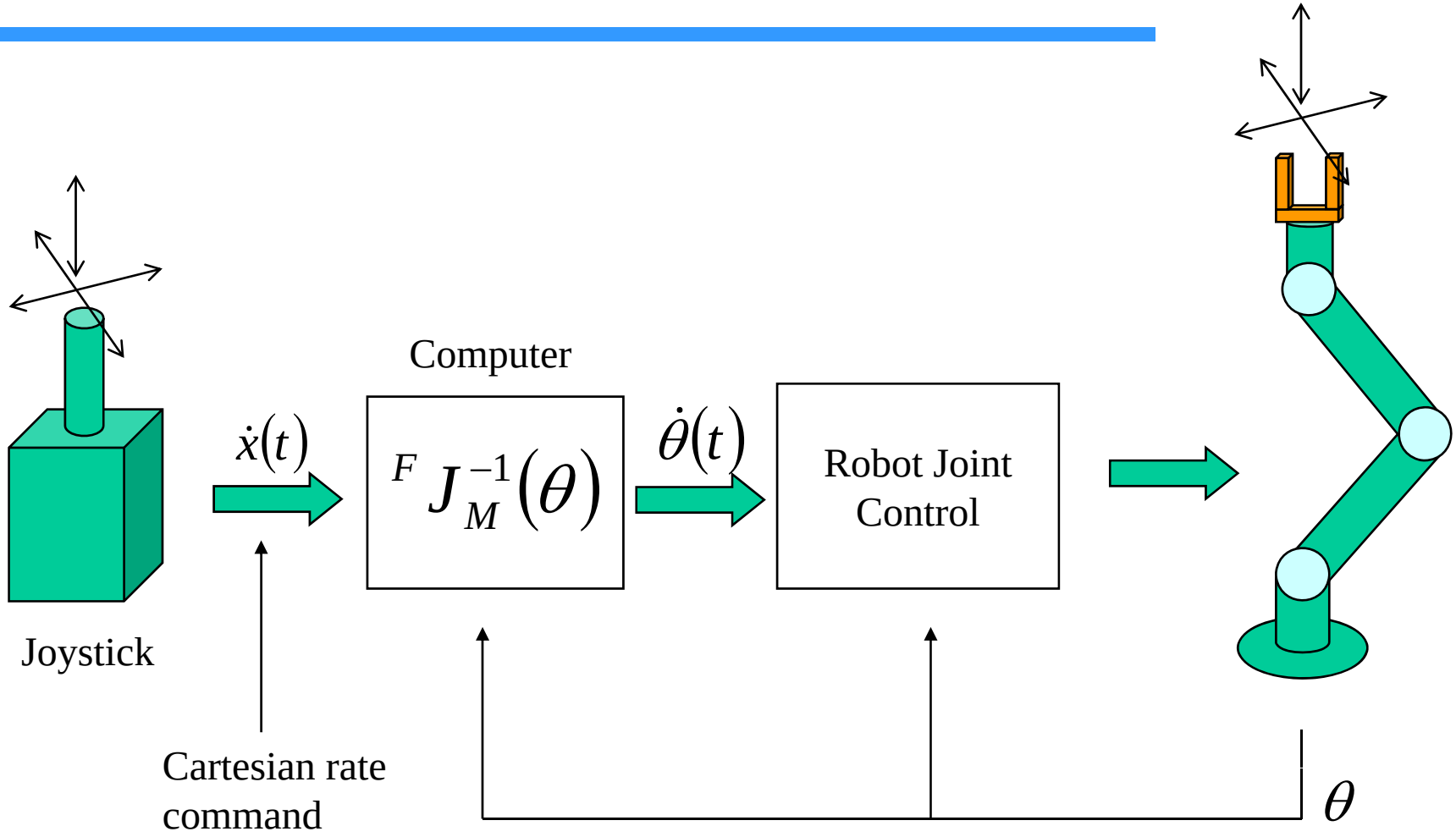
Advantage

Cheap (usually no computer or sensors are required)

Disadvantage

Human must do inverse kinematics in their hand !

Resolved Rate Control

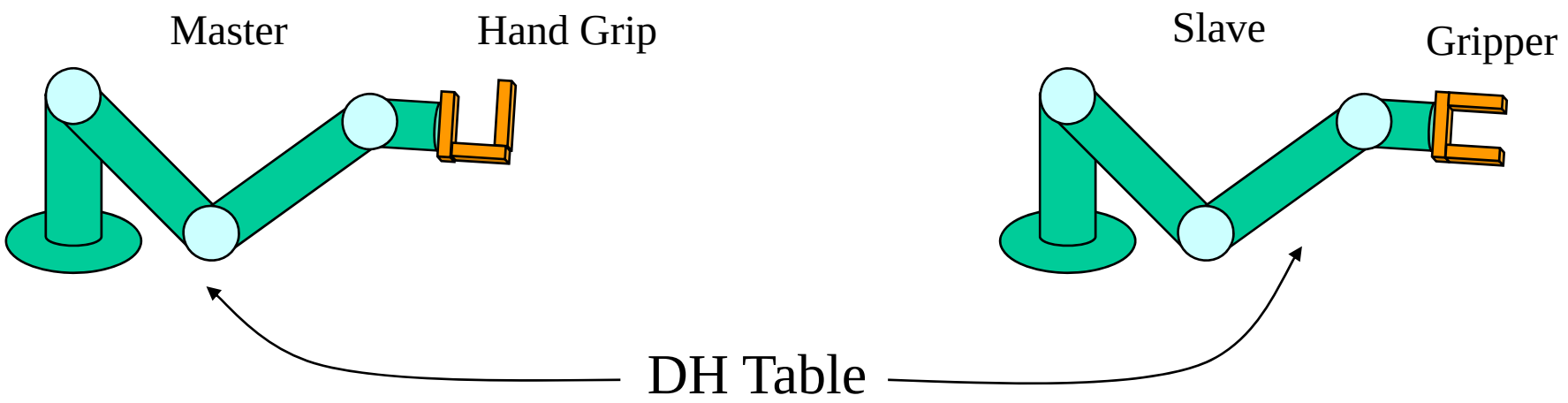


Resolved Rate Control (cont.)

- *Advantage*
  - Modest computation requirements
  - Can be adapted to task (ex. Change ref. frame or ref. PT)

- *Disadvantage*
  - Cognitive load:
    - operator must differentiate desired trajectory
    - rate control of orientation is difficult
  - Watch out for singularities
    - system may demand infinite joint rates from robot

Master/Slave Control (Homeo morphie)



Definitions

- Indexing: provision of an arbitrary offset between master and slave configurations
- Scaling: ability to multiply position commands by an arbitrary constant

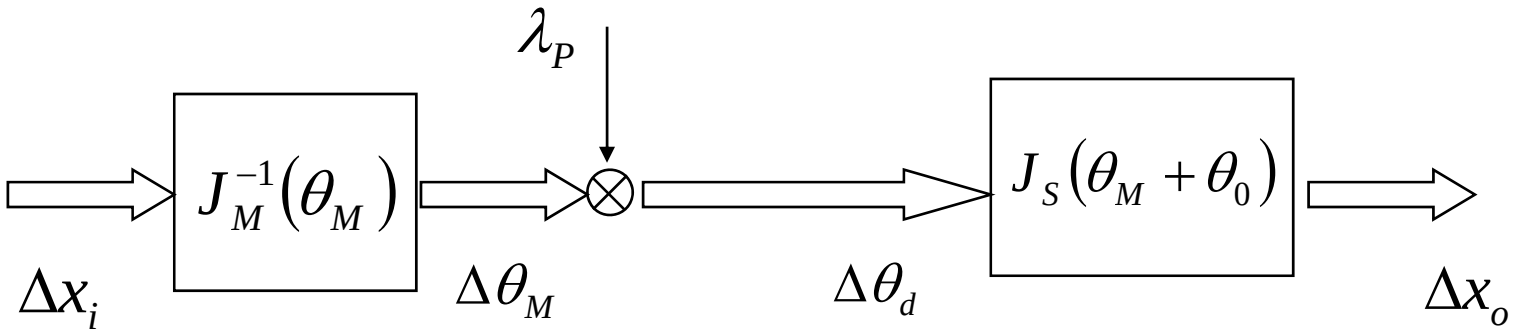
Master/Slave Control (cont.)

- *Advantage*
  - Simple architecture (eg. 6 analog controller)
  - Good operator interface (1:1 motion and force control)

- *Disadvantage*
  - Master and slave must be same design
  - Master and slave must be in same configuration

Master/Slave Control (cont.)

Consider a M/S system which is moved by Δx_i at the master resulting in slave motion Δx_o



If $\lambda_P = 1$ and $\theta_0 = 0$ then

$$\theta_M = \theta_S, \quad J_M(\theta_M) = J_S(\theta_S)$$

and

$$\Delta x_o = J_S(\theta_S) J_M^{-1}(\theta_M) \Delta x_i = \Delta x_i$$

Master/Slave Control (cont.)

Index

$$if\ \theta_o \neq 0,\quad \theta_S = \theta_M + \theta_o$$

$$J_S(\theta_M + \theta_o)J_M^{-1}(\theta_M) \neq I$$

Scale

$$if\ \lambda_P \neq 1,\quad \theta_S = \lambda_P \theta_M$$

$$J_S(\lambda_P \theta_M)J_M^{-1}(\theta_M) \neq \lambda_P$$

Controller must make sure that

$$\theta_S = \theta_M$$