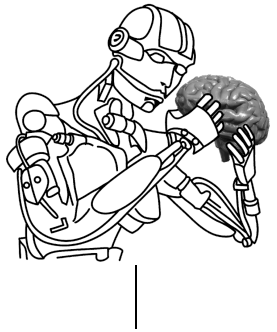
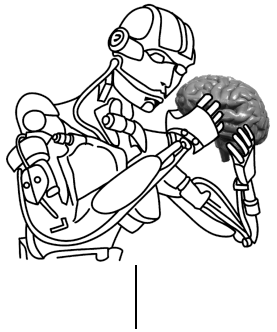
# CS545—Contents V



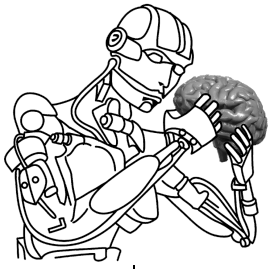
- Case Study: An Artificial Eye System
  - Introduction to Oculomotor Control
  - The model of the dynamics
  - Gaze stabilization
  - The vestibulo-ocular reflex (VOR)
  - The optokinetic reflex (OKR)
  - Delays
  - Controlling the VOR and OKR
- Reading Assignment for Next Class
  - See http://www-clmc.usc.edu/~cs545

# Introduction to Oculomotor Control

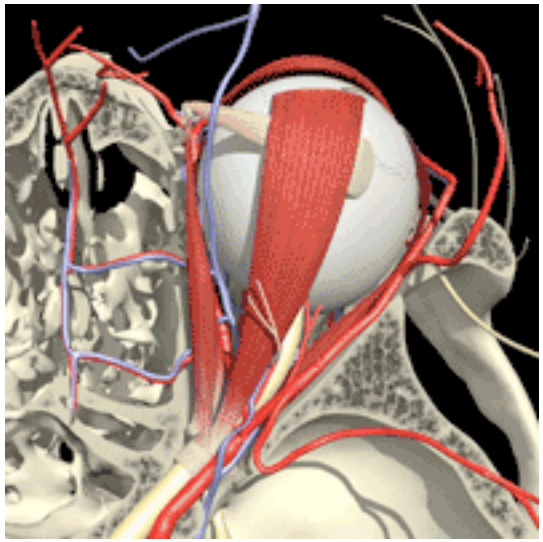


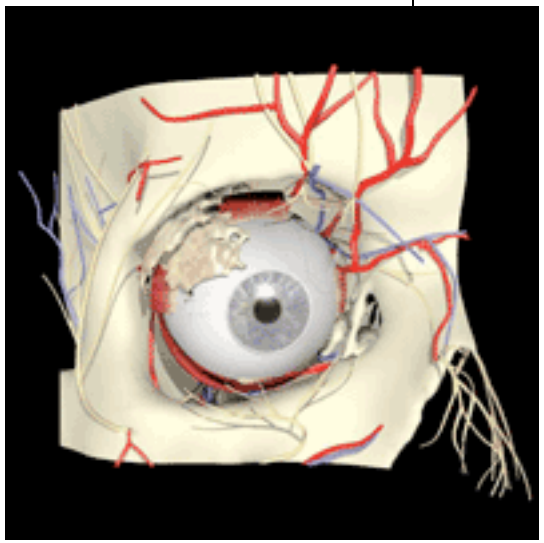
- Goals
  - Get visual input from the entire world with high resolution foveal vision and low resolution peripheral vision
- Behaviors
  - Move the fovea to interesting targets (saccades)
  - Stabilize target on retina (VOR,OKR)
  - Adjust focal length (accommodation)
  - Enable stereo vision (vergence)
  - Avoid workspace boundaries (nystagmus)
- Problems
  - Delays from visual processing are about 100ms in humans, about 30-100ms in artificial systems

# Example Oculomotor Systems

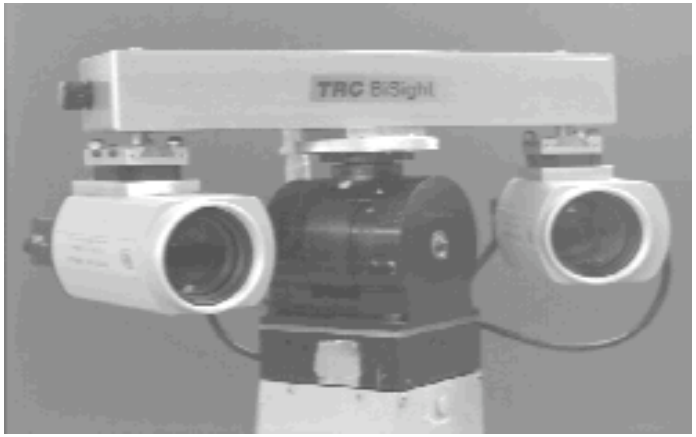


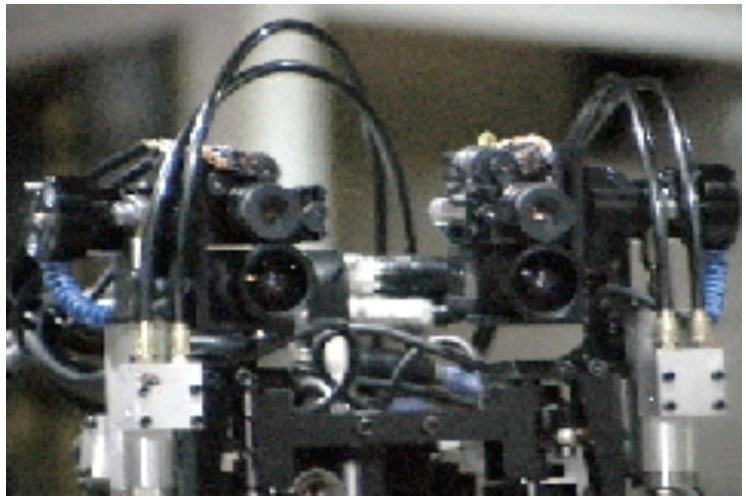
- The human eye



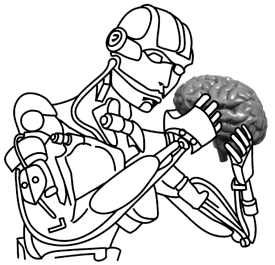


- Vision Heads

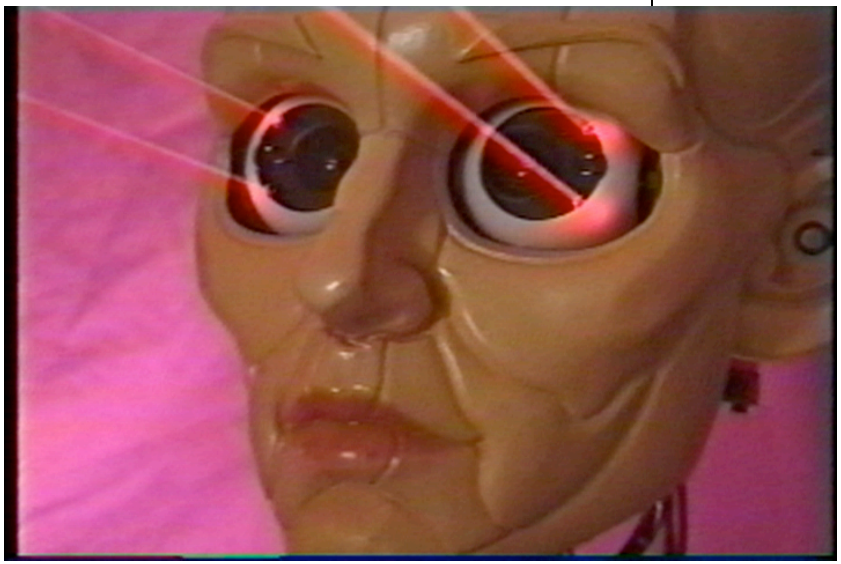


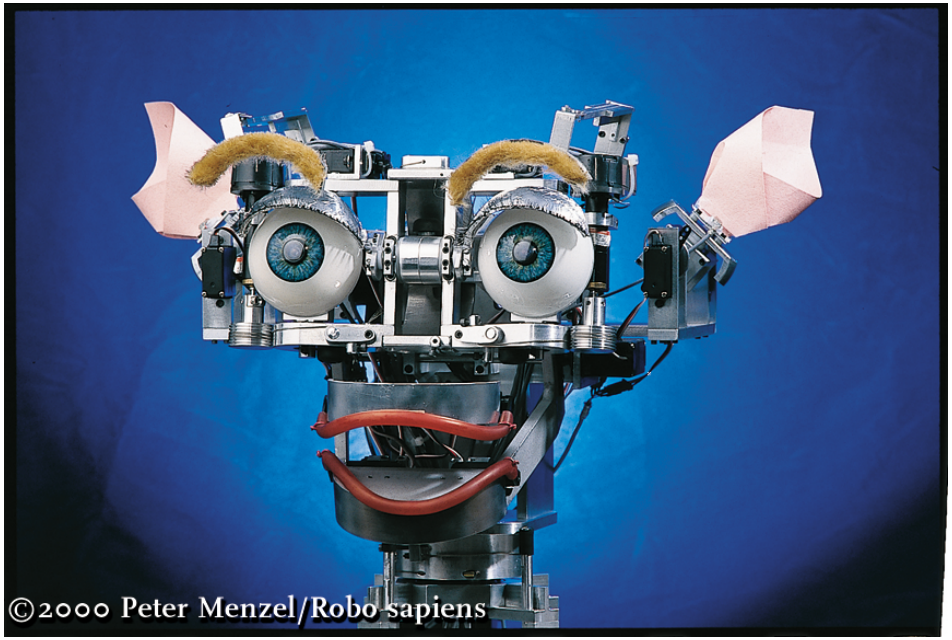



# Example Oculomotor Systems

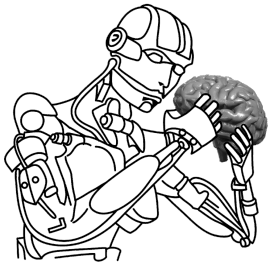


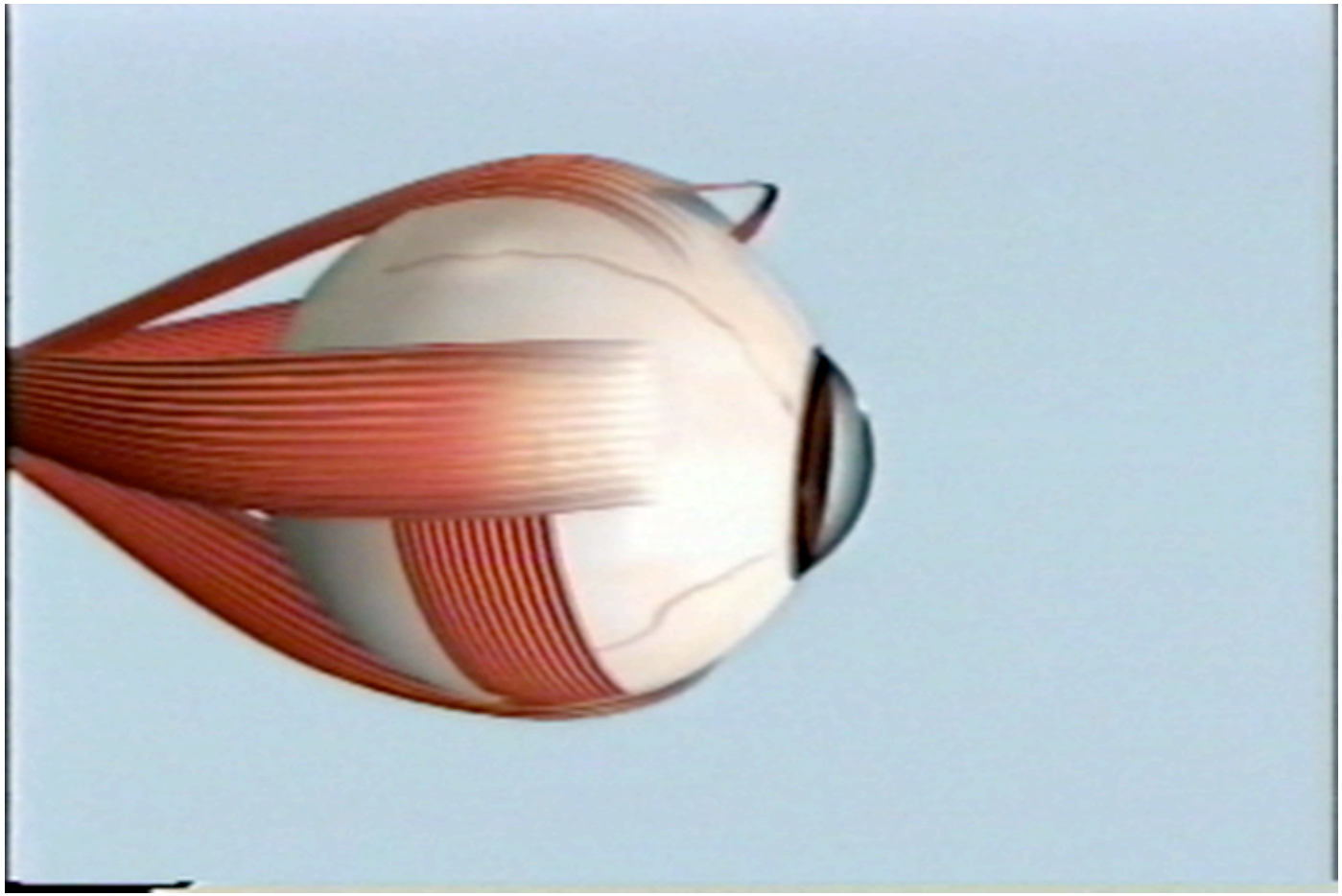
- Vision Heads



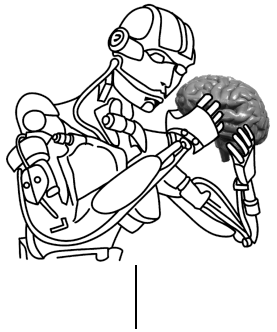


# Case Study:
# The VOR and OKR



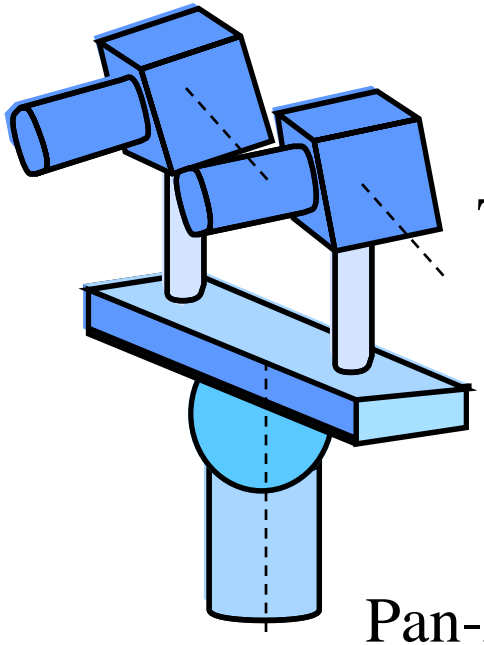


# A model of the eye system

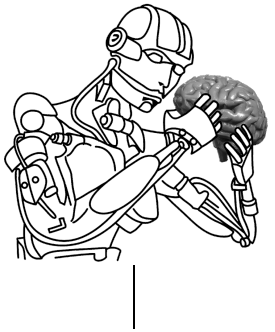


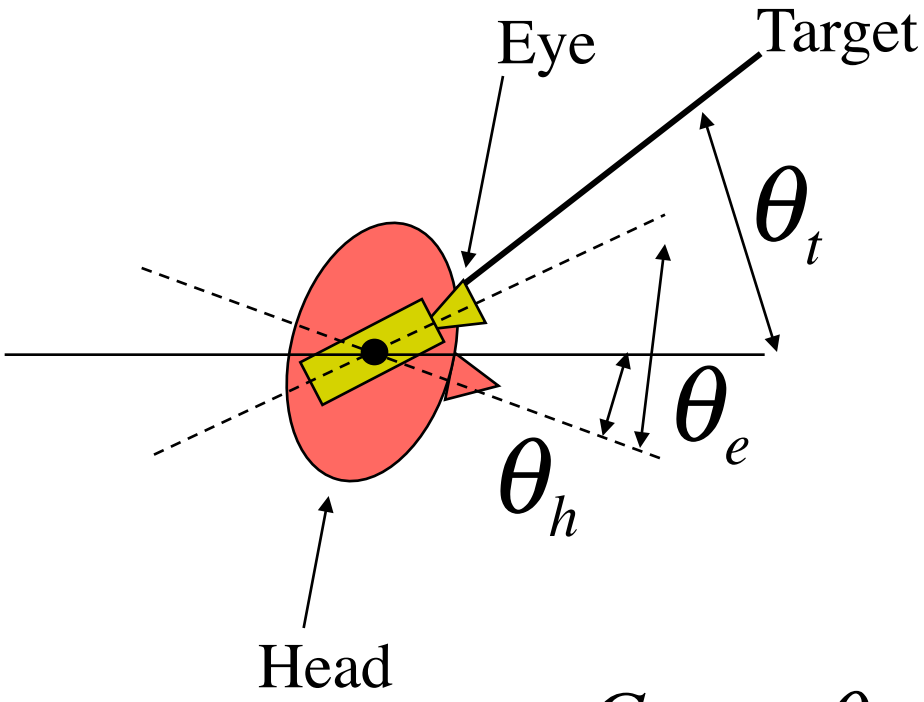
- Assumptions:
  - System is a linear second order system
  - Eye motors are very strong (inertial loads are small)
  - Independent control of pan and tilt degree-of-freedom, thus:

$$I\ddot{\theta} = -b\dot{\theta} - k\theta + \tau$$



# Gaze Stabilization

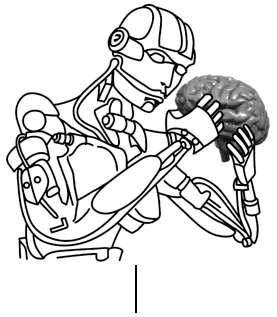


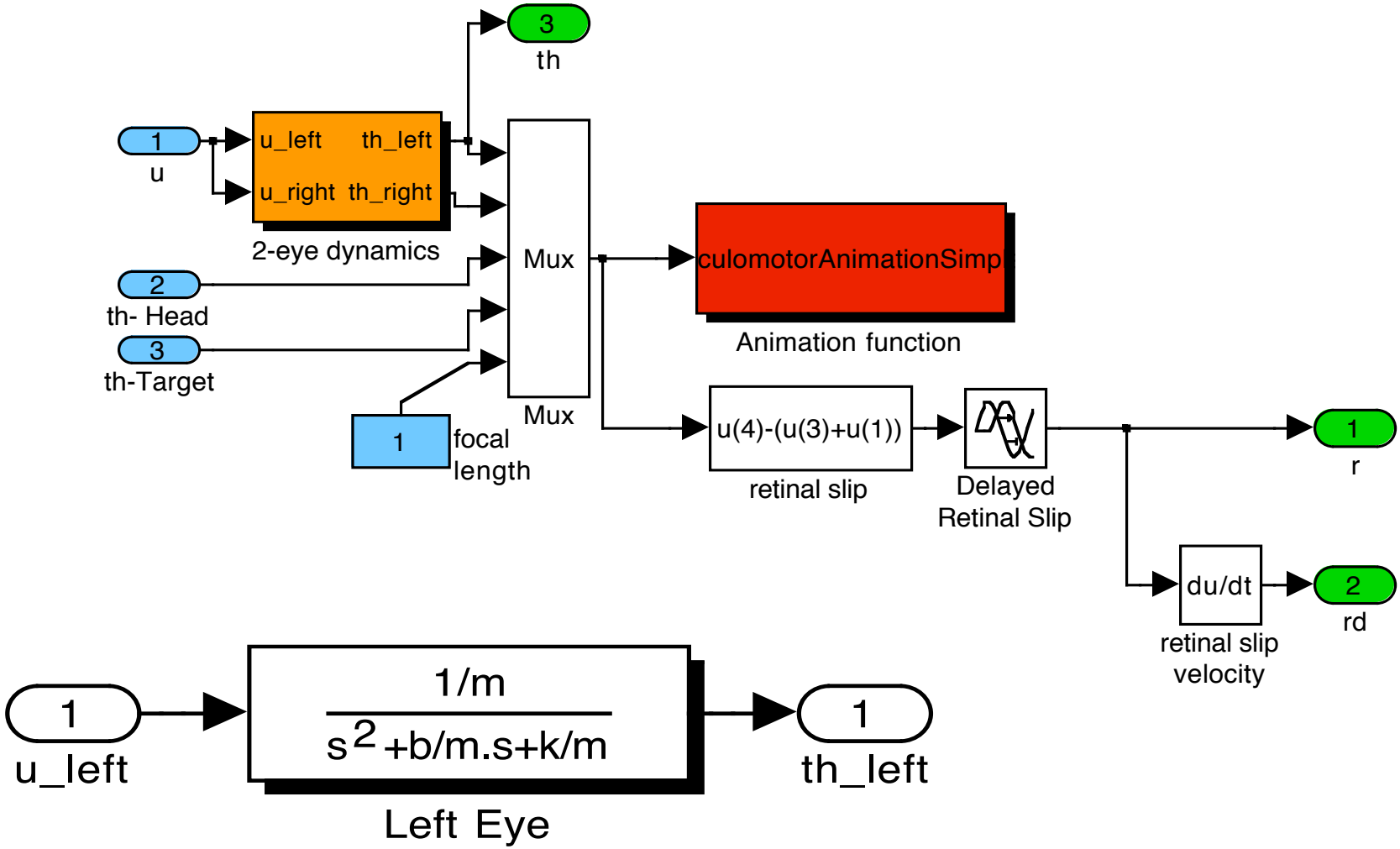



$$Gaze = \theta_e + \theta_h$$

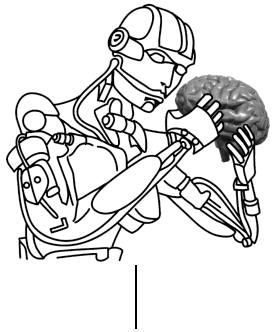
Goal: keep the eye on the target in case of visual and head perturbations!

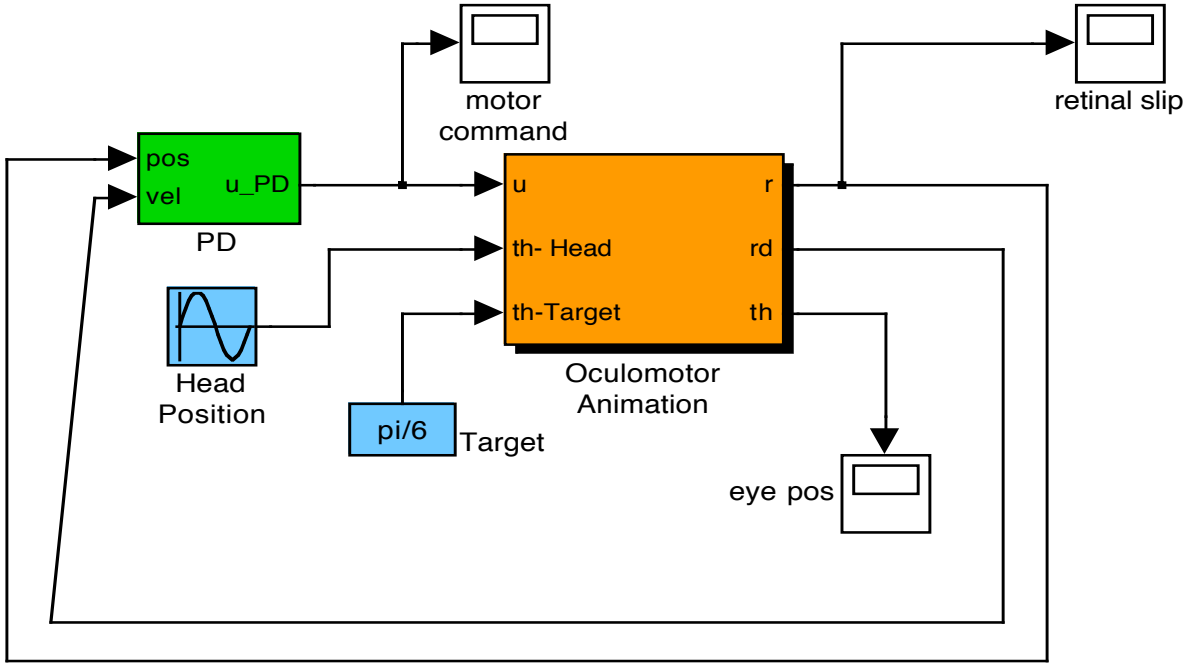
# Simulink Model of Oculomotor System

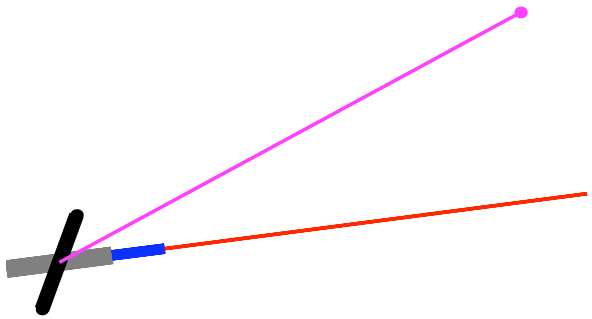




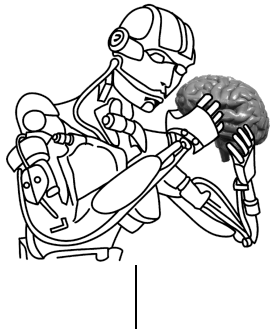
# PD Control for the VOR &OKR





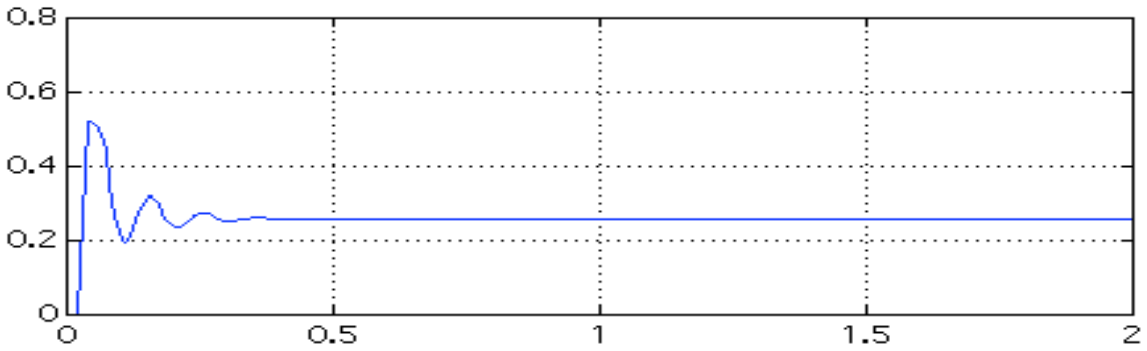



# Performance of PD Control



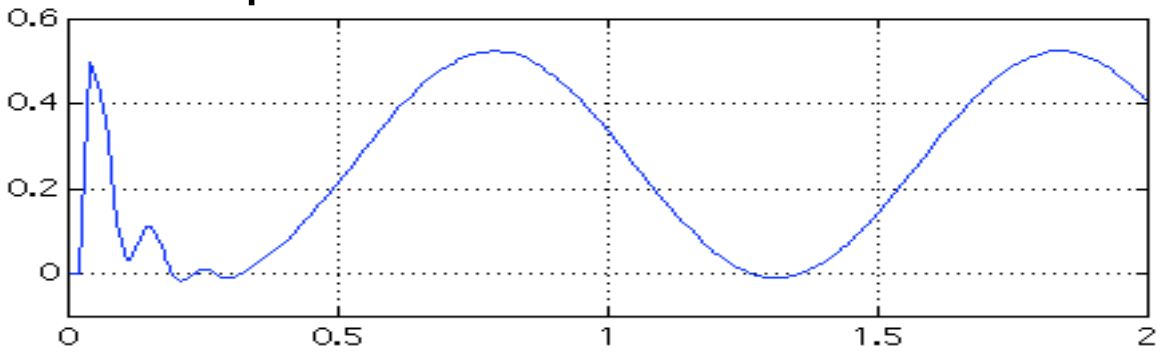
- Step Input:

retinal slip

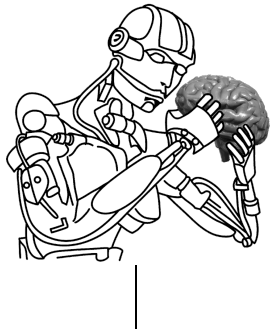



time

- Sinusoidal Input



# How to Improve Performance?



- Integrator
- Feedforward Control
- Delay Compensation