

Reflex Control of Walking

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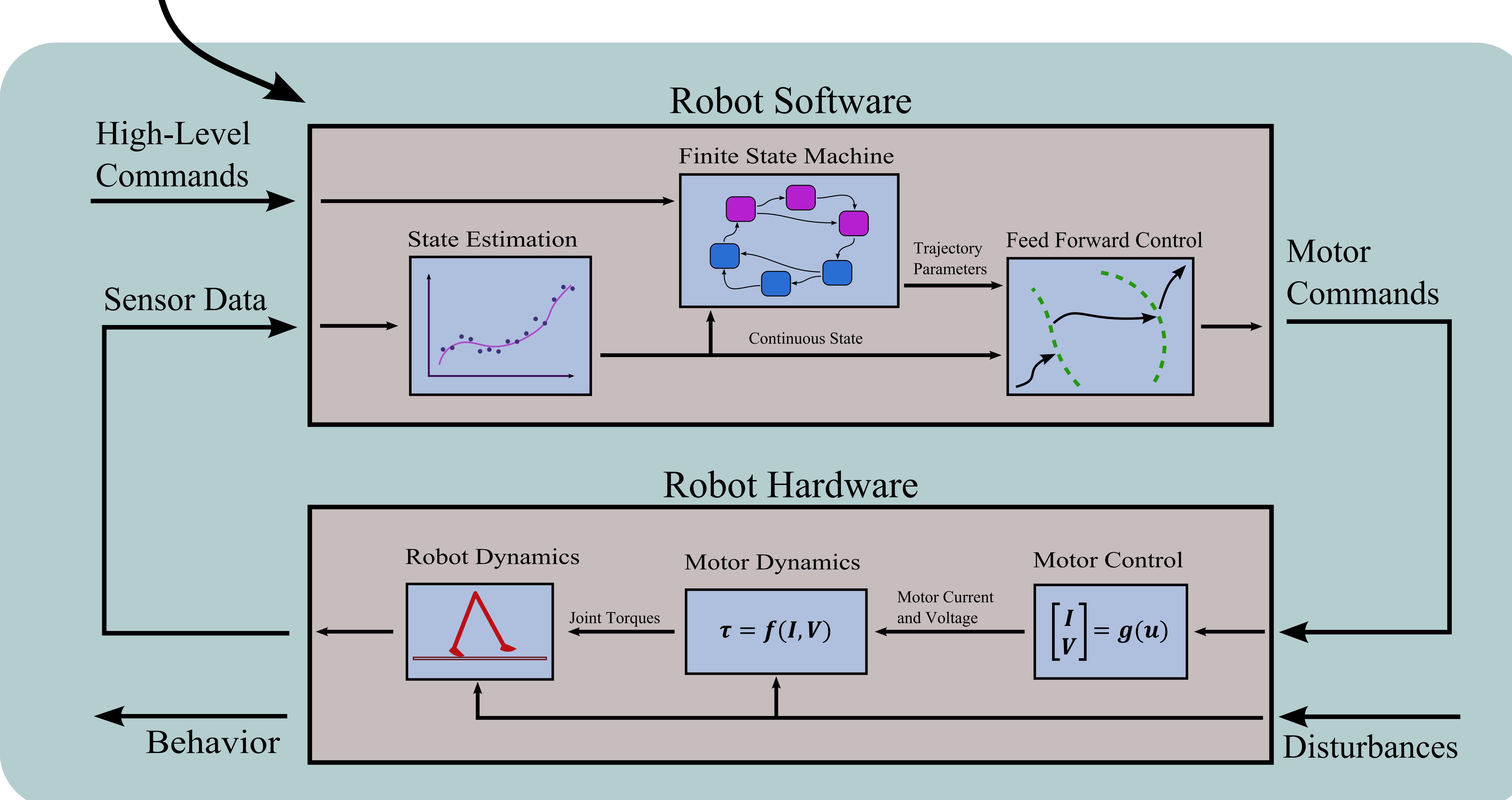
Mechanical Engineering, Cornell University



Reflex Control:

- Event-based
- Feed forward
- Sparse (few couplings)
- Impedance control

Implementation:



Motivation / Background:

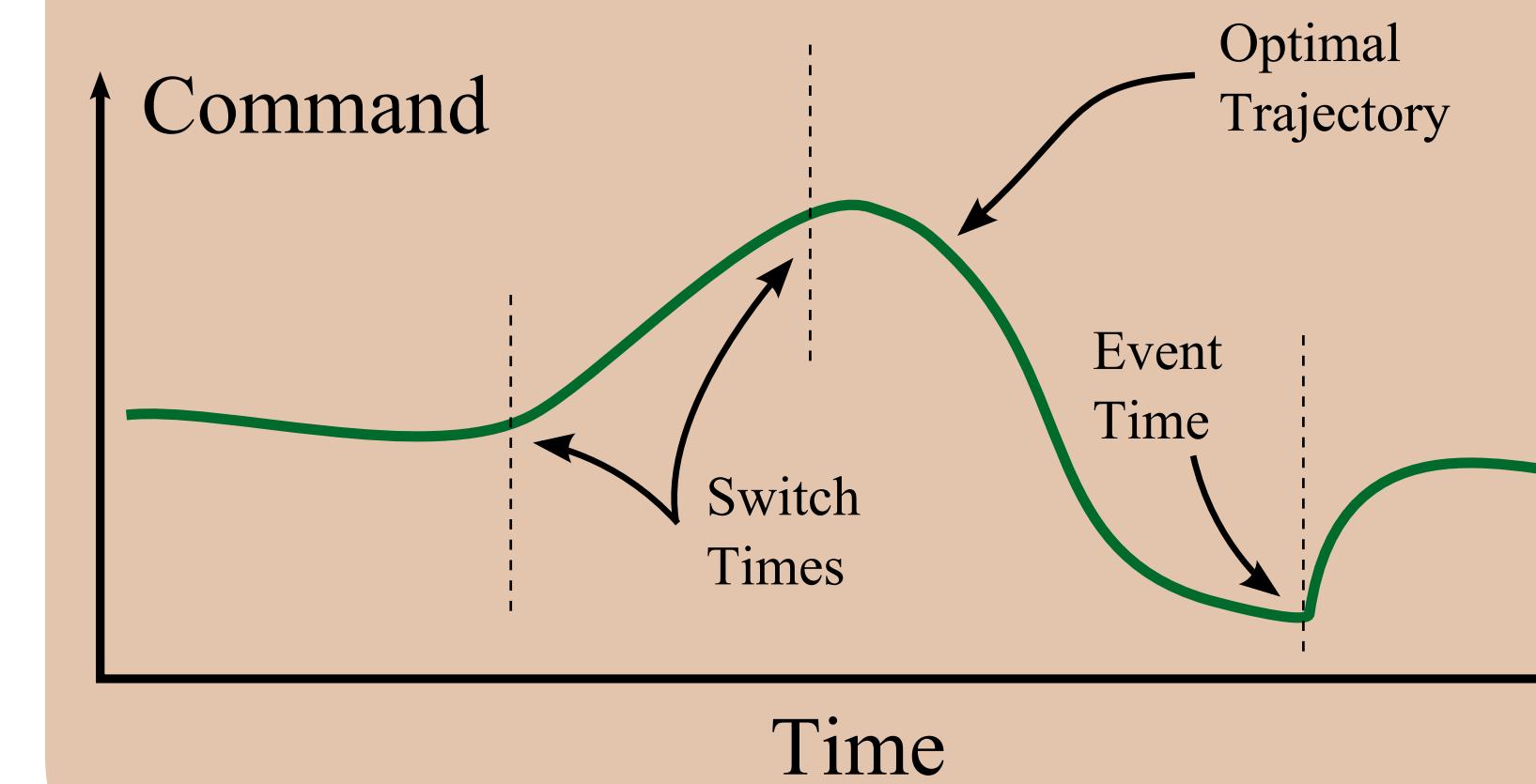
- 1) Facilitate:
 - Control design
 - Learning
 - Optimization
- 2) Features:
 - Few control parameters
 - Generalizable
 - Avoids over fitting
 - Handles time delays
- 3) Used on Cornell Ranger
 - Walked 65 km
 - *But*, not systematically optimized for stability



Design Algorithm:

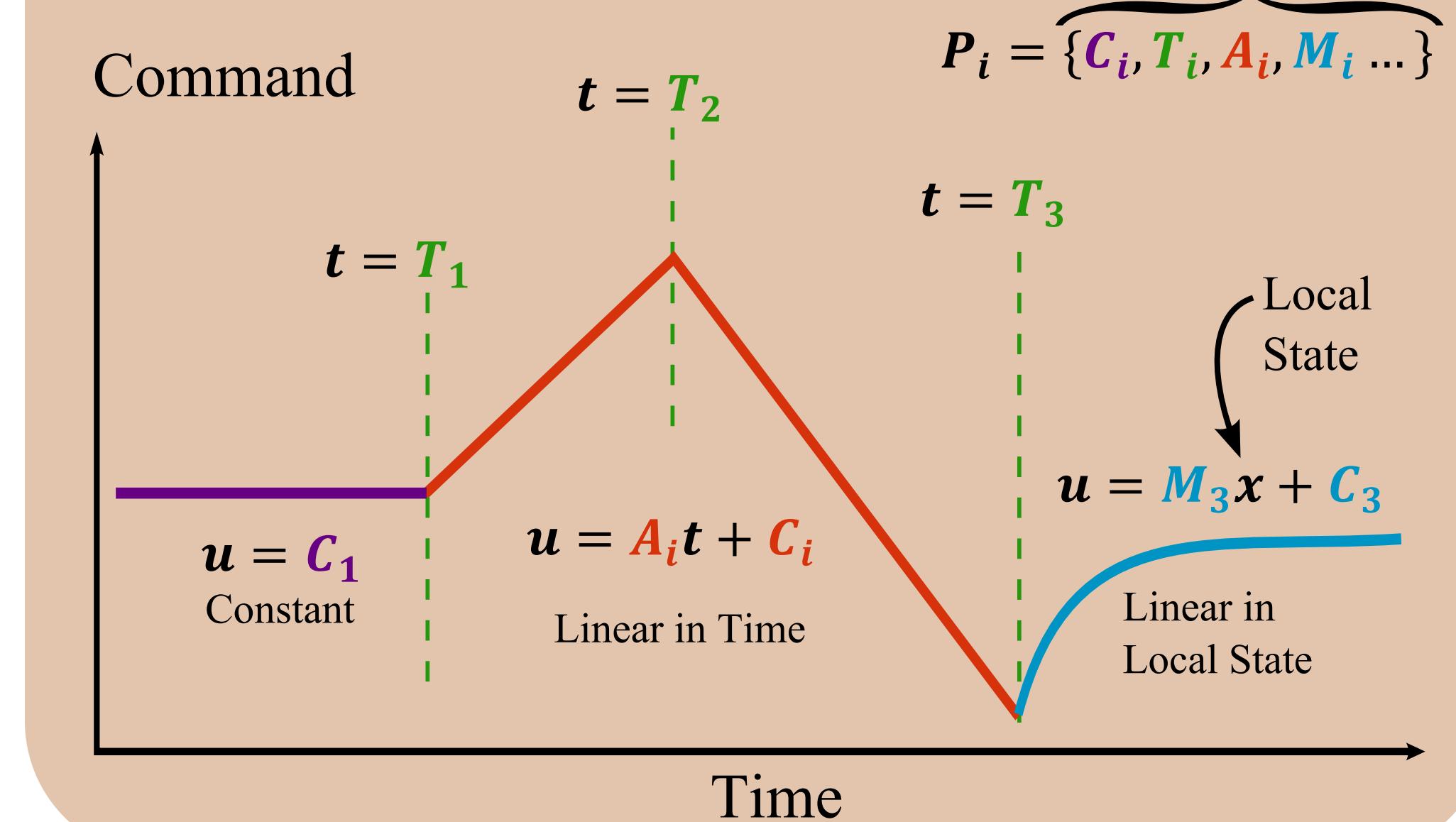
1) Trajectory Optimization

Fine grid, offline, model based



2) Representation with Few Parameters

Approximate using simple piecewise functions



3) Stabilizing Controller Design

What? Find optimal policy : $P_i^* = \pi_i^*(s_i)$

How? Policy Iteration :

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INIT:  $\pi_i'(s_i)$  for  $s_i \in S_i$ 
LOOP: i Until  $\pi_i$  Converges
FOR:  $s_i \in S_i$ 
   $\pi_i(s_i) := \pi_i'(s_i)$ 
   $V_{\pi_i}(s_i) = R_i(s_i, \pi_i(s_i)) + \gamma V_{\pi_{i+1}}(s_{i+1})$ 
   $\pi_i'(s_i) := \text{argmax}_{P_i} (R_i(s_i, P_i) + \gamma V_{\pi_{i+1}}(s_{i+1}))$ 
FIT:  $V_{\pi_i}(\bullet)$  and  $\pi_i'(\bullet)$  for  $s_i \in S_i$ 
  
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State at start of section i

Reward for trajectory from s_i to s_{i+1}

$V_{\pi_i}(s_i)$ = Value Function

$R_i(s_i, P_i)$ = Reward Function

γ = Discount Factor

Value for reaching state s_{i+1}

Discussion:

- 1) How to automate architecture choices?
- 2) Representation of policy and value function?
- 3) How to initialize policy?
- 4) Best reward function?
- 5) Policy iteration convergence?