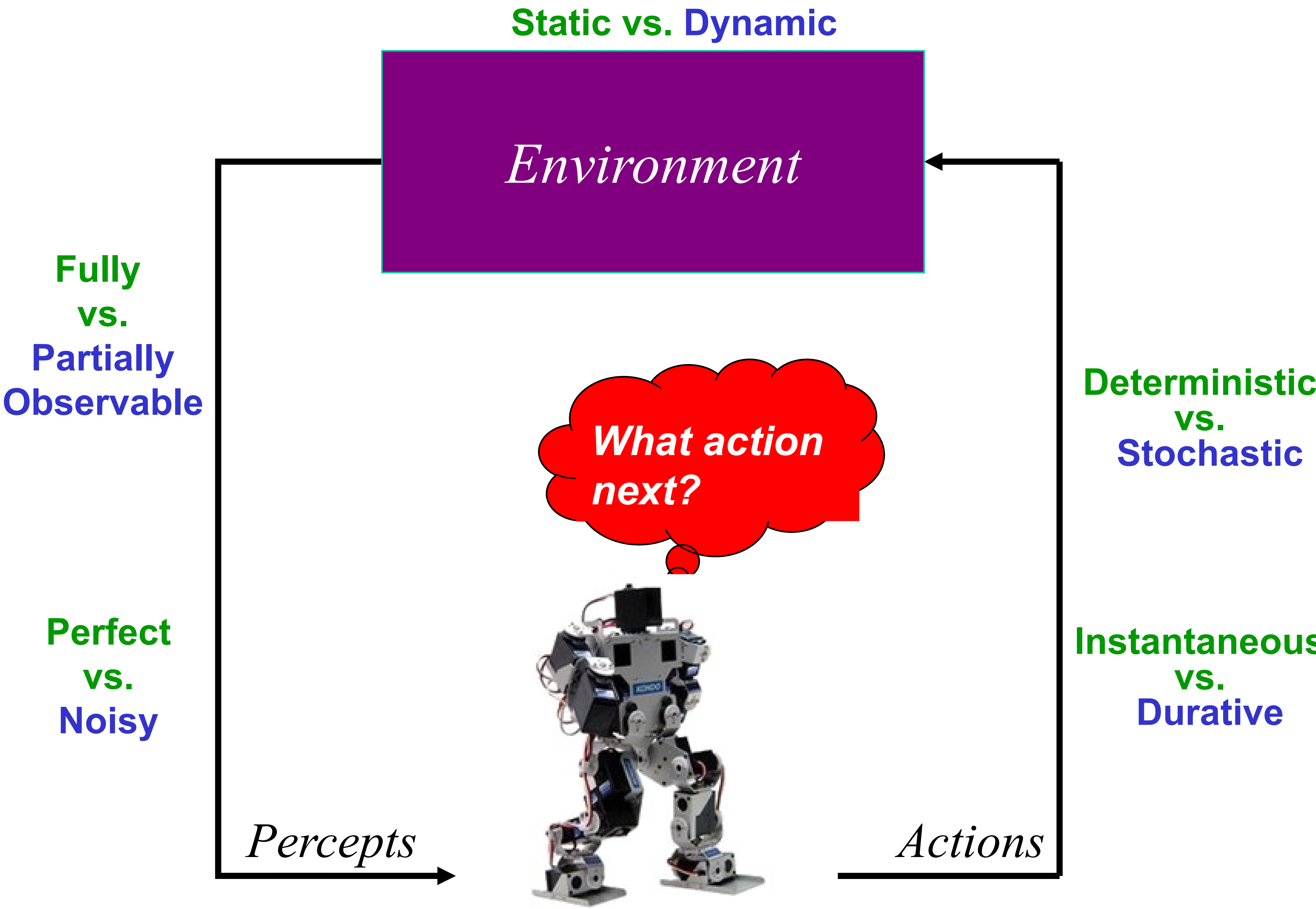
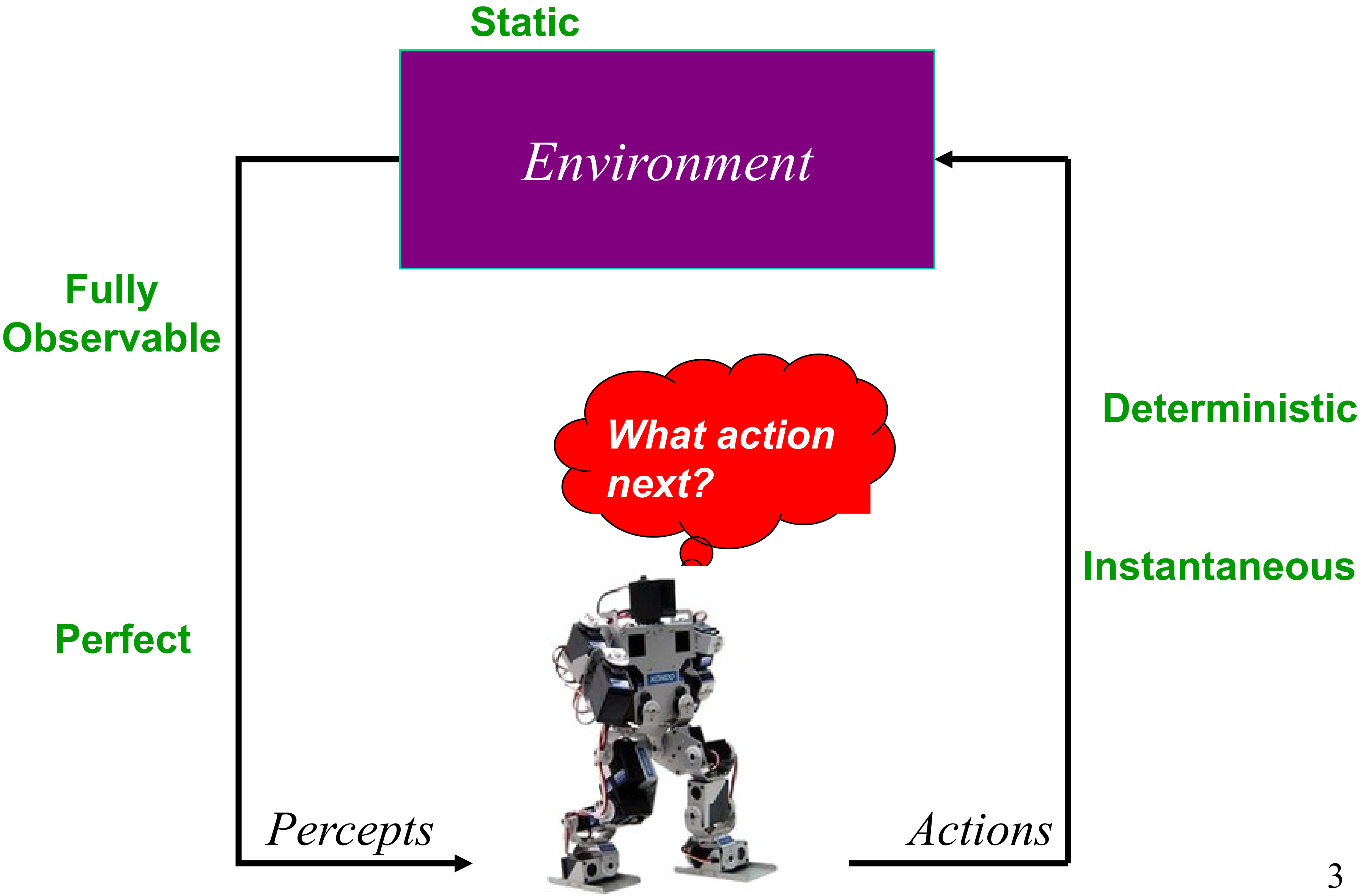
Markov Decision Processes
Chapter 17

Mausam

Planning Agent



Search Algorithms

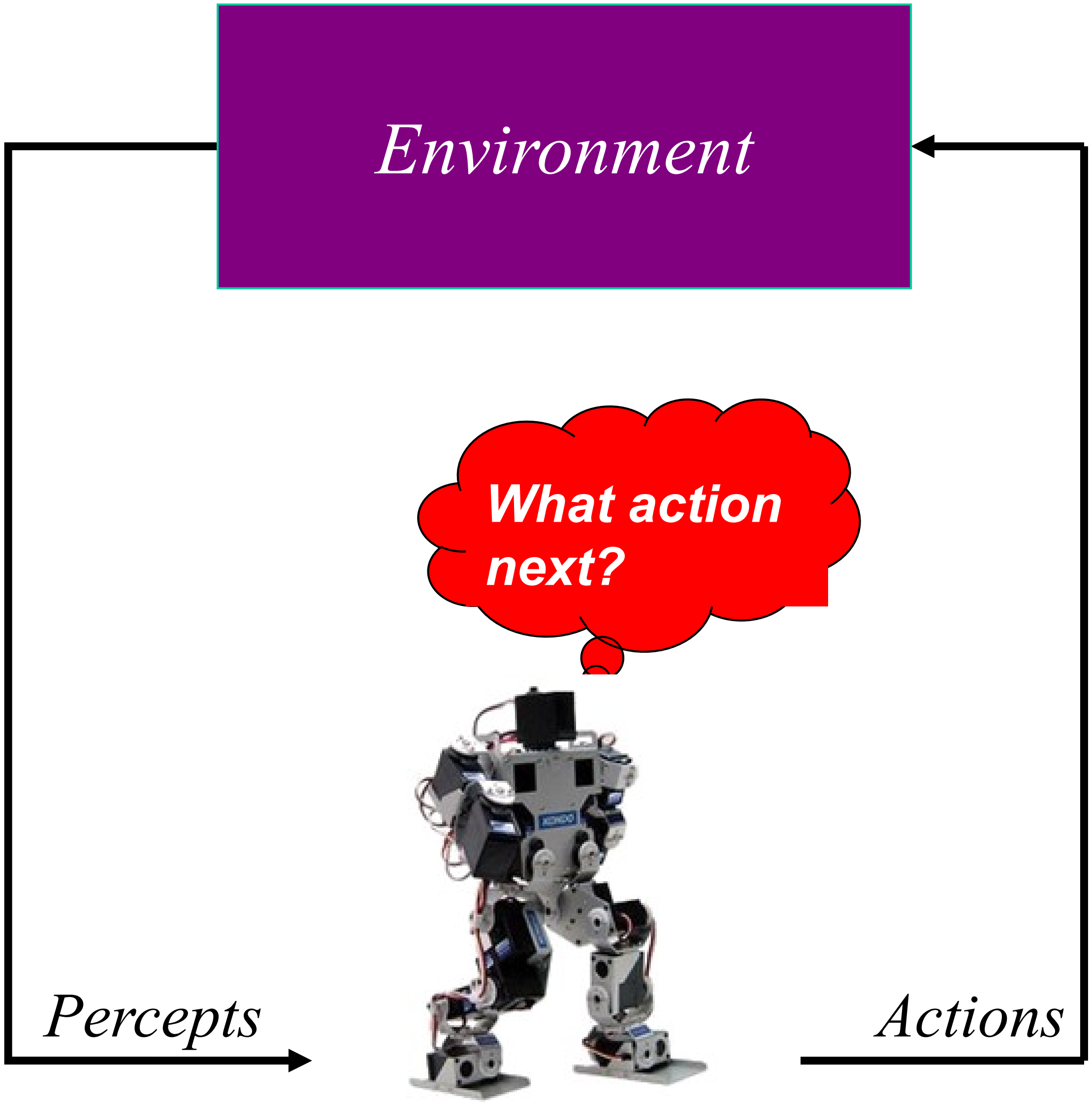


Stochastic Planning: MDPs

Static

Fully Observable

Perfect



Stochastic

Instantaneous

MDP vs. Decision Theory

- Decision theory - episodic
- MDP -- sequential

Markov Decision Process (MDP)

- $\mathcal{S}$: A set of states
- $\mathcal{A}$: A set of actions
- $\mathcal{T}$(s,a,s'): transition model
- $\mathcal{C}$(s,a,s'): cost model
- $\mathcal{G}$: set of goals
- s_0: start state
- γ: discount factor
- $\mathcal{R}$(s,a,s'): reward model

factored

Factored MDP

absorbing/
non-absorbing

Objective of an MDP

- Find a policy $\pi: \mathcal{S} \rightarrow \mathcal{A}$

- which optimizes

$$\begin{array}{l}\bullet\ \text{minimizes}\\ \bullet\ \text{maximizes}\\ \bullet\ \text{maximizes}\end{array} \begin{pmatrix}\text{discounted}\\ \text{or}\\ \text{undiscount.}\end{pmatrix} \begin{array}{l}\text{expected cost to reach a goal}\\ \text{expected reward}\\ \text{expected (reward-cost)}\end{array}$$

- given a ____ horizon
  - finite
  - infinite
  - indefinite

- assuming full observability

Role of Discount Factor (γ)

- Keep the total reward/total cost finite
  - useful for infinite horizon problems

- Intuition (economics):
  - Money today is worth more than money tomorrow.

- Total reward: $r_1 + \gamma r_2 + \gamma^2 r_3 + \ldots$
- Total cost: $c_1 + \gamma c_2 + \gamma^2 c_3 + \ldots$

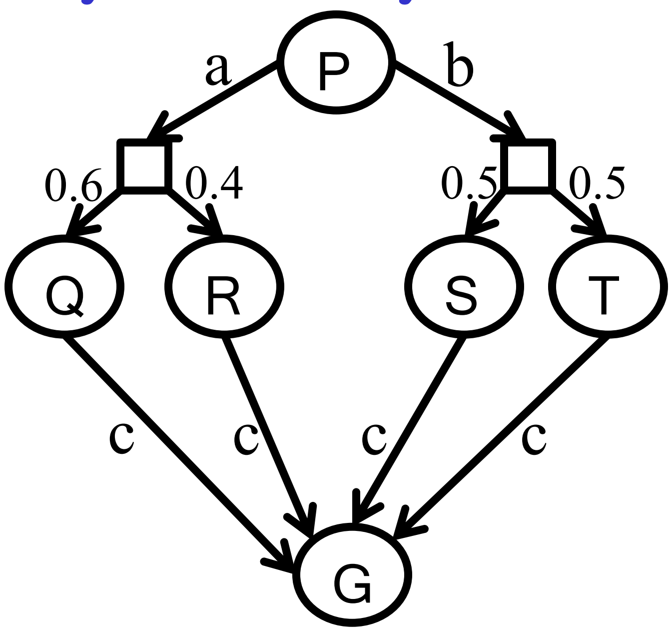
Examples of MDPs

- Goal-directed, Indefinite Horizon, Cost Minimization MDP
  - <$\mathcal{S}$, $\mathcal{A}$, $\mathcal{T}$, $\mathcal{C}$, $\mathcal{G}$, s_0>
  - Most often studied in planning, graph theory communities
- Infinite Horizon, Discounted Reward Maximization MDP
  - <$\mathcal{S}$, $\mathcal{A}$, $\mathcal{T}$, $\mathcal{R}$, γ>
  - Most often studied in machine learning, economics, operations research communities

most popular

- Oversubscription Planning: Non absorbing goals, Reward Max. MDP
  - <$\mathcal{S}$, $\mathcal{A}$, $\mathcal{T}$, $\mathcal{G}$, $\mathcal{R}$, s_0>
  - Relatively recent model

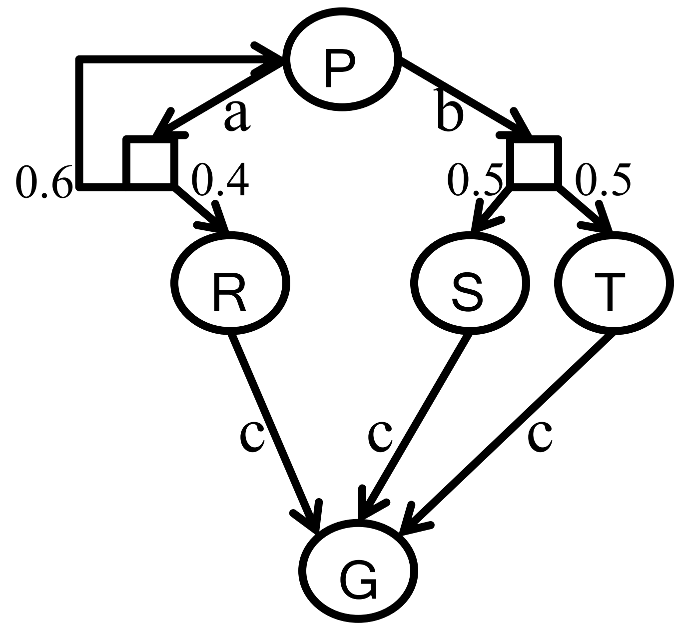
Acyclic vs. Cyclic MDPs



C(a) = 5, C(b) = 10, C(c) =1

Expectimin works

- V(Q/R/S/T) = 1
- V(P) = 6 – action a



Expectimin doesn't work

- infinite loop

- V(R/S/T) = 1
- Q(P,b) = 11
- Q(P,a) = ????
- suppose I decide to take a in P
- Q(P,a) = 5+ 0.4*1 + 0.6Q(P,a)
- ➔ = 13.5