Robot grocery shopping in partially observable settings

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Outline

1. Background on POMDPs
2. Grocery shopping as planning in a POMDP
3. Demo!
4. What worked
5. What failed

Background

A *partially observable Markov decision process* (POMDP) is a collection of objects (S, A, Ω, R, T, O)

S: state space

A: action space

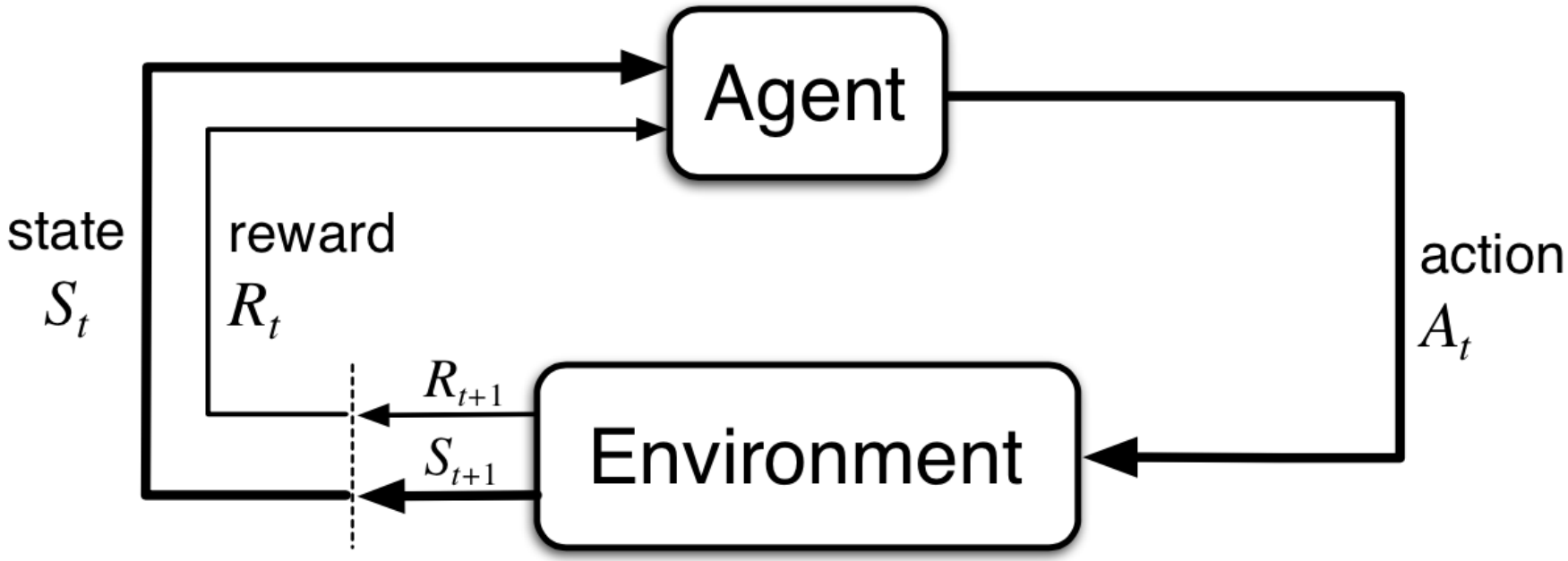
Ω: observation space

$R : S \times A \to \mathbb{R}$ reward function

T: transition operator. $T(s' \mid s, a)$ is probability of next state s' given state s and action a

O: observable operator. $O(o \mid s)$ is probability of observing o given at state s

Background



Belief-state MDP

Implemented MDP solvers:

- Q-learning
- SARSA
- R-MAX
- Thompson sampling

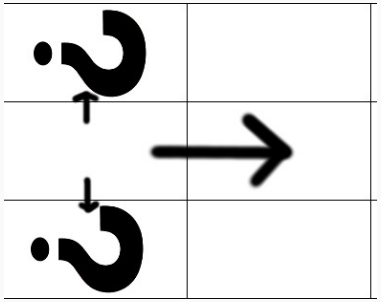
There are a lot!

- Function approximations with adaptive basis functions
- BOSS
- Spectral methods
- Skill chaining
- ...

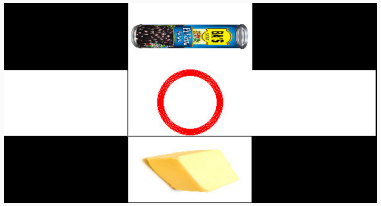
Grocery shopping

Grid World POMDP

Uncertain movement



Can only see around current cell (partially observable)



World is not fully known beforehand

- Model of how items in the same aisle correlate.
- Unknown arrangement of aisles
- Unknown arrangement of items within aisles

Grocery shopping

pygame running the visuals

Every second:

- Agent provides next action based on current belief state
- Simulator executes action (errors may happen)
- Belief state is updated based on transition probabilities
- Belief state is updated based on observation
- Belief about the world is updated based on belief state, and observation

Challenges:

- Markov assumption is not completely accurate
- Bias towards increasing probability of most likely states

DEMO

Our working solver

Max Probability Value Iteration:

Choose the most likely state from belief state to run value iteration

Our working solver

Value iteration:

$$
\begin{aligned}
v_{k+1}(s) &= \max_a \mathbb{E}[R_{t+1} + \gamma v_k(S_{t+1}) \mid S_t = s, A_t = a] \\
&= \max_a \sum_{s'} p(s' \mid s, a)[r(s, a, s') + \gamma v_k(s')]
\end{aligned}
$$

Failed tasks

Value iteration as a belief-state MDP

Thompson sampling

...

Play with it!

github.com/dustinvtran/bayesrl