Fast Action Elimination for Efficient Decision Making and Belief Space Planning Using Bounded Approximations

Khen Elimelech & Vadim Indelman

TECHNION Israel Institute of Technology

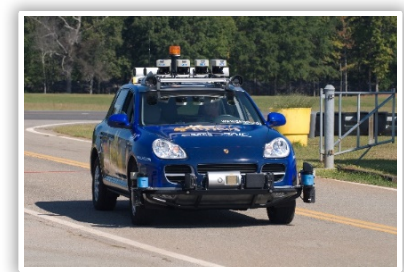
ANPL Autonomous Navigation and Perception Lab

International Symposium on Robotics Research (ISRR)

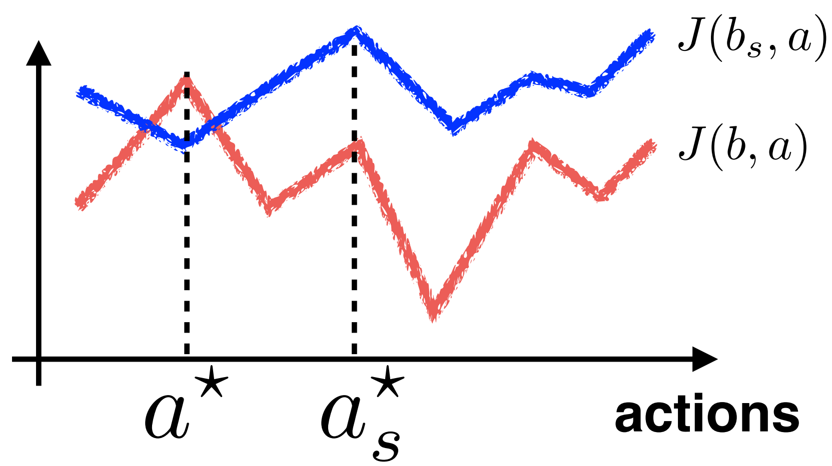
December 2017

The Mission

Computationally efficient online decision making and belief space planning



Our approach: Use rough state (belief) approximations $b \longrightarrow b_s$
to **easily eliminate unfit candidates**

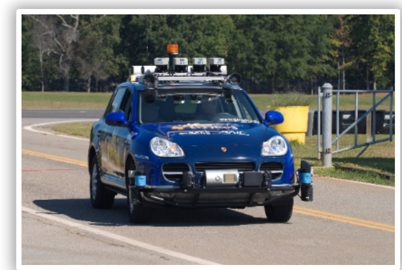


Computationally cheaper
to evaluate

ANPL | Autonomous Navigation and Perception Lab
TECHNION Israel Institute of Technology

The Mission

Computationally efficient online decision making and belief space planning

Our approach: Use rough state (belief) approximations $b \longrightarrow b_s$ to **easily eliminate unfit candidates**

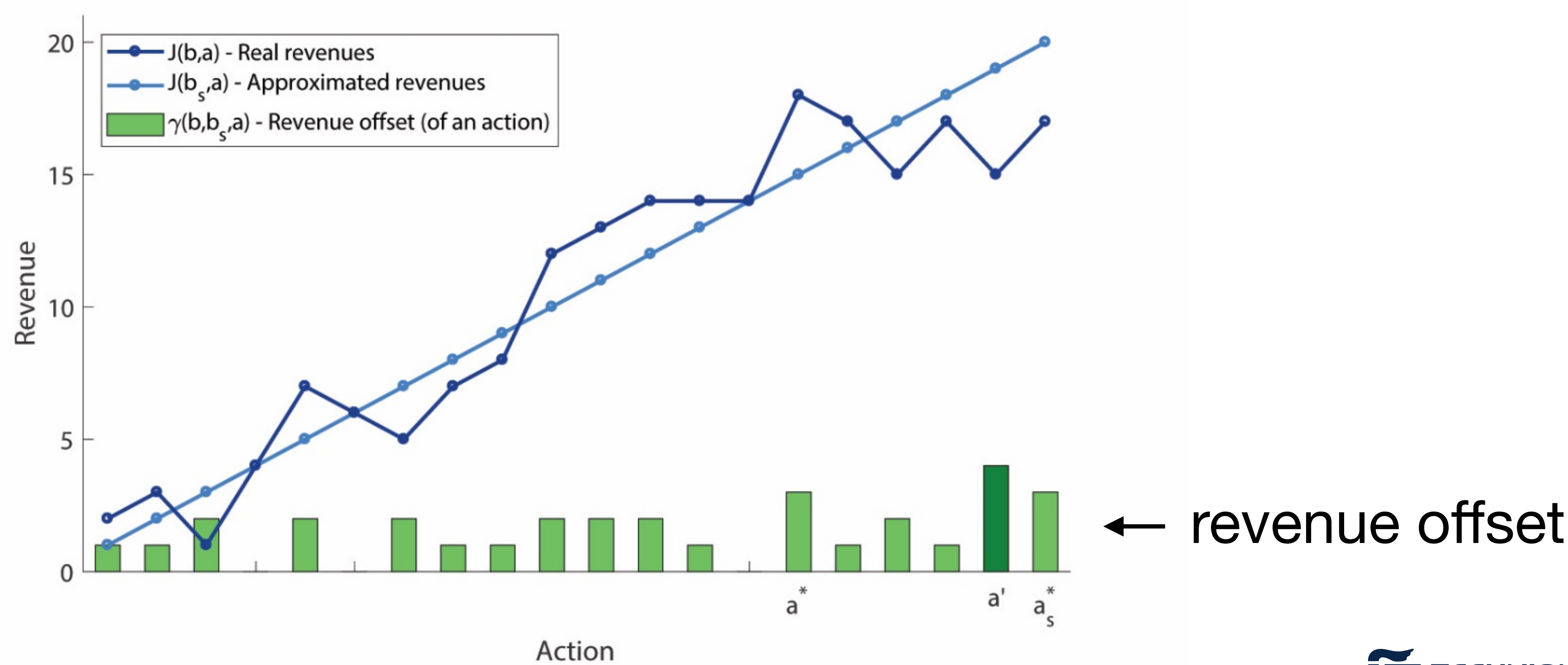
- Same quality of solution
- Not restricted to a specific problem
- Can be used alongside any other optimization method
- Focusing on **planning under uncertainty**

Method Overview

- Use a rough state (belief) approximation b_s to easily **calculate the expected revenues (for different candidate actions)**
- Revenue offset definition

$$\gamma(b, b_s, a) \doteq |J(b,a) - J(b_s, a)|$$

$$\gamma(b, b_s) \doteq \max_{a \in \mathcal{A}} \gamma(b, b_s, a)$$



ANPL Autonomous Navigation and Perception Lab
TECHNION Israel Institute of Technology

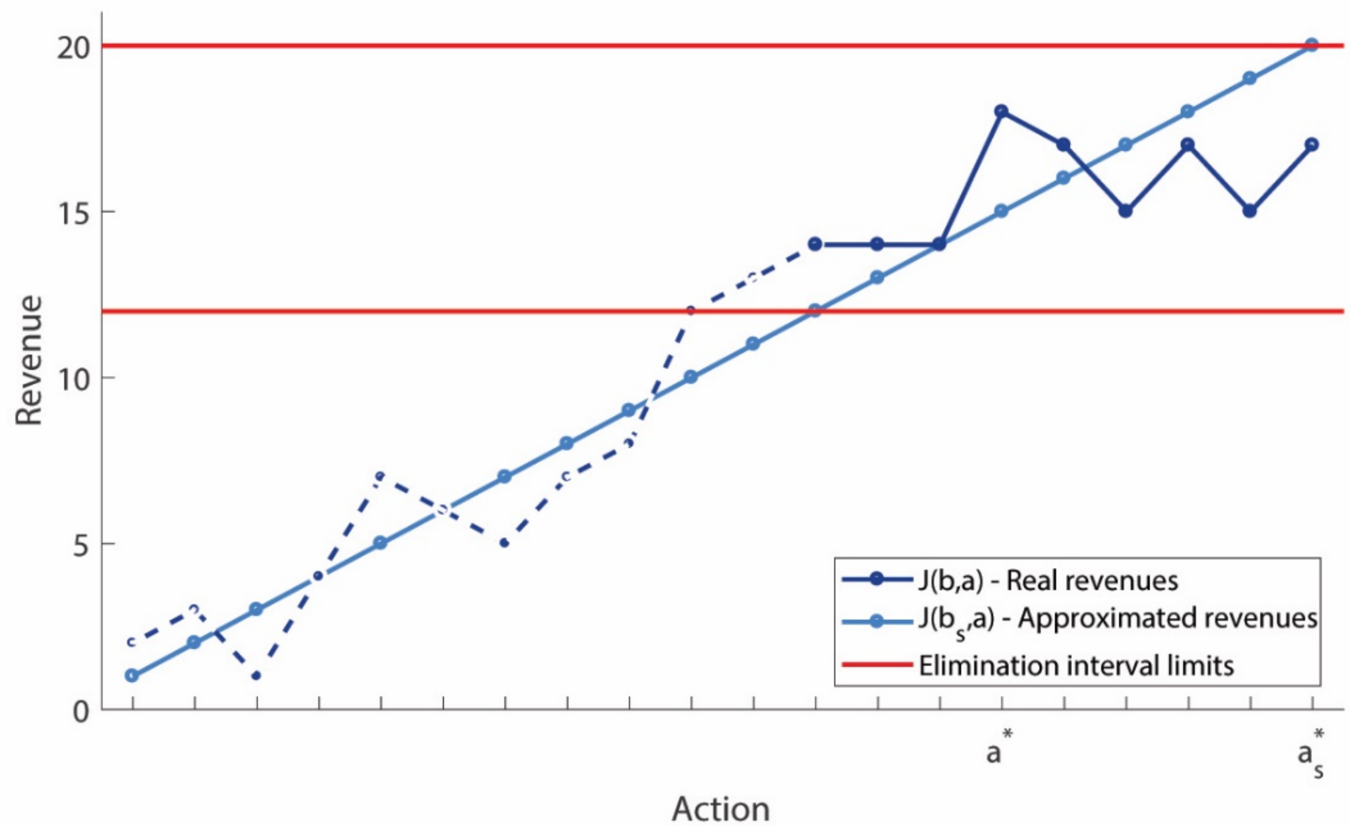
Method Overview

- Given (a bound on) the revenue offset, define the **elimination interval**

$$J(b_s, a_s^*) - 2 \cdot \gamma(b, b_s) \quad \leq \quad J(b_s, a^*) \quad \leq \quad J(b_s, a_s^*)$$

$$a^* = \underset{a}{\operatorname{argmax}}\, J(b,a)$$
$$a_s^* = \underset{a}{\operatorname{argmax}}\, J(b_s,a)$$

- Eliminate all candidates outside this interval - **guaranteed** not to be optimal
- Solve the problem for a **subset of candidates**



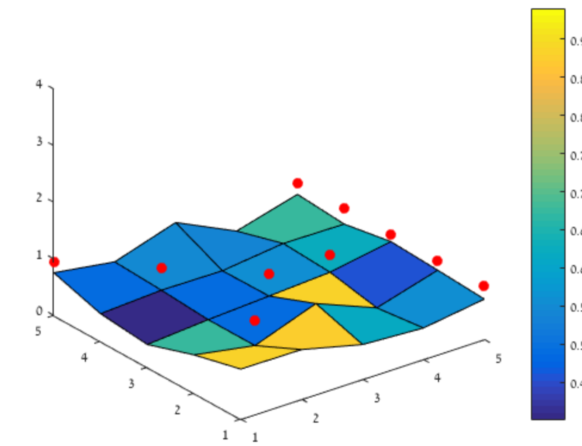
Calculate real revenues only within elim. interval

K. Elimelech and V. Indelman,
Fast Action Elimination for Efficient Decision Making and Belief Space Planning Using Bounded Approximations

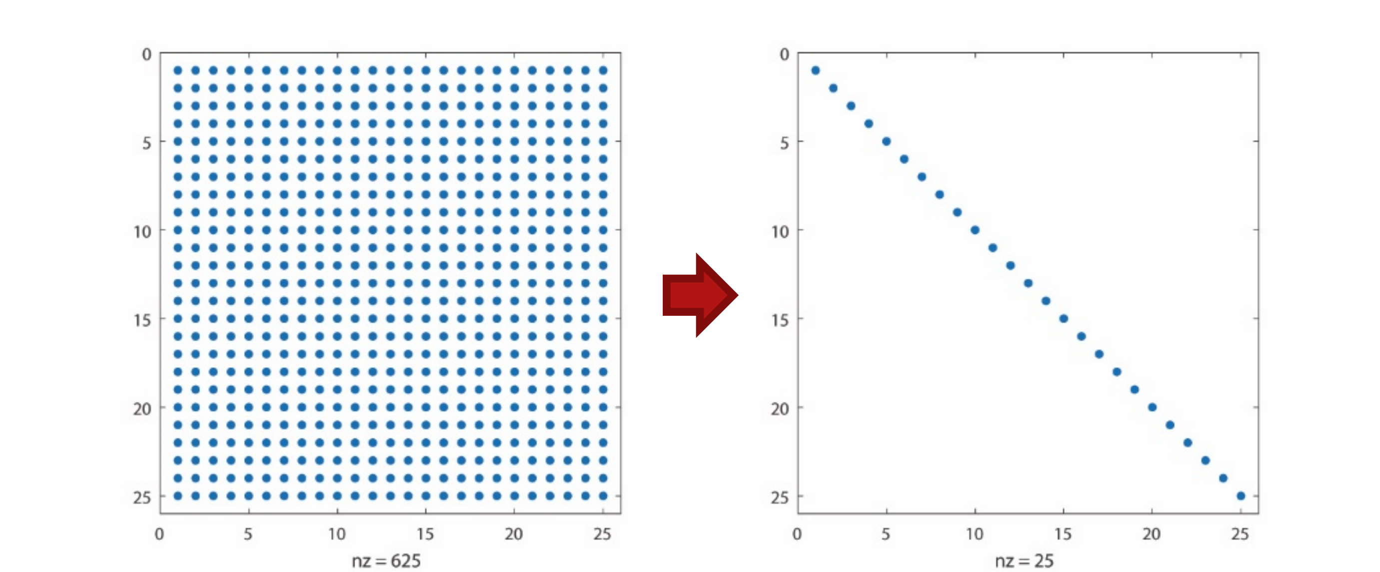
ANPL Autonomous Navigation and Perception Lab
TECHNION Israel Institute of Technology

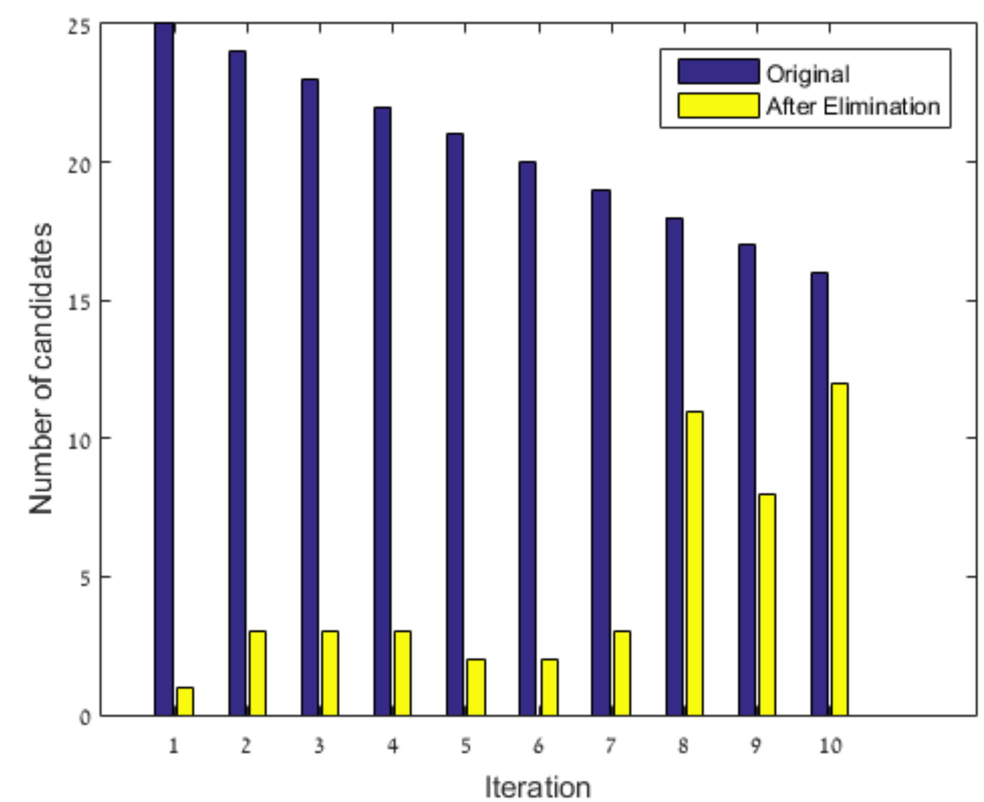
Results: Sensor Placement

- Decision making under uncertainty
- At each step, find the most informative sensor placement
- Elimination of unbeneficial sensor positions



- Using sparse belief approximations (see also [RA-L'16, ICRA'17, IROS'17])





K. Elimelech and V. Indelman,
Fast Action Elimination for Efficient Decision Making and Belief Space Planning Using Bounded Approximations

ANPL Autonomous Navigation and Perception Lab
TECHNION Israel Institute of Technology