ROIL: Robust Offline Imitation Learning

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Summary

Motivation

- **Need better offline IRL methods**
- Learning from data in a robust offline way is important in many fields, like health care, robotics or finance
- Existing methods are not robust to covariate shift

Limitations of existing methods

- Reliance on $\hat{u}_e$ leads to covariate shift for off-policy datasets
- Inability to specify reliance on $\hat{u}_e$
- **No guarantees of policy convergence to u_e even when every state is visited**

Our contributions

- New algorithm for robust offline imitation learning
- Guaranteed convergence to the optimal policy for tabular domains
- Flexibility to define the reliance on $\hat{u}_e$

IRL

- Methods that learn a policy from expert demonstrations and a model of the environment
- **Goal**: Learn a policy that is close to the expert's
- **On-policy**: State visitation frequency is the same as the expert's
- **Off-policy**: State visitation frequency is *different* from the expert's

Not Occupancy Frequency Matching

- Many methods rely on matching the occupancy frequencies of the expert and the learned policy
- LPAL, GAIL, MILO, ect
- When off-policy, $\hat{u}_e$ is not close to u_e
- ROIL avoids this by not relying on $\hat{u}_e$

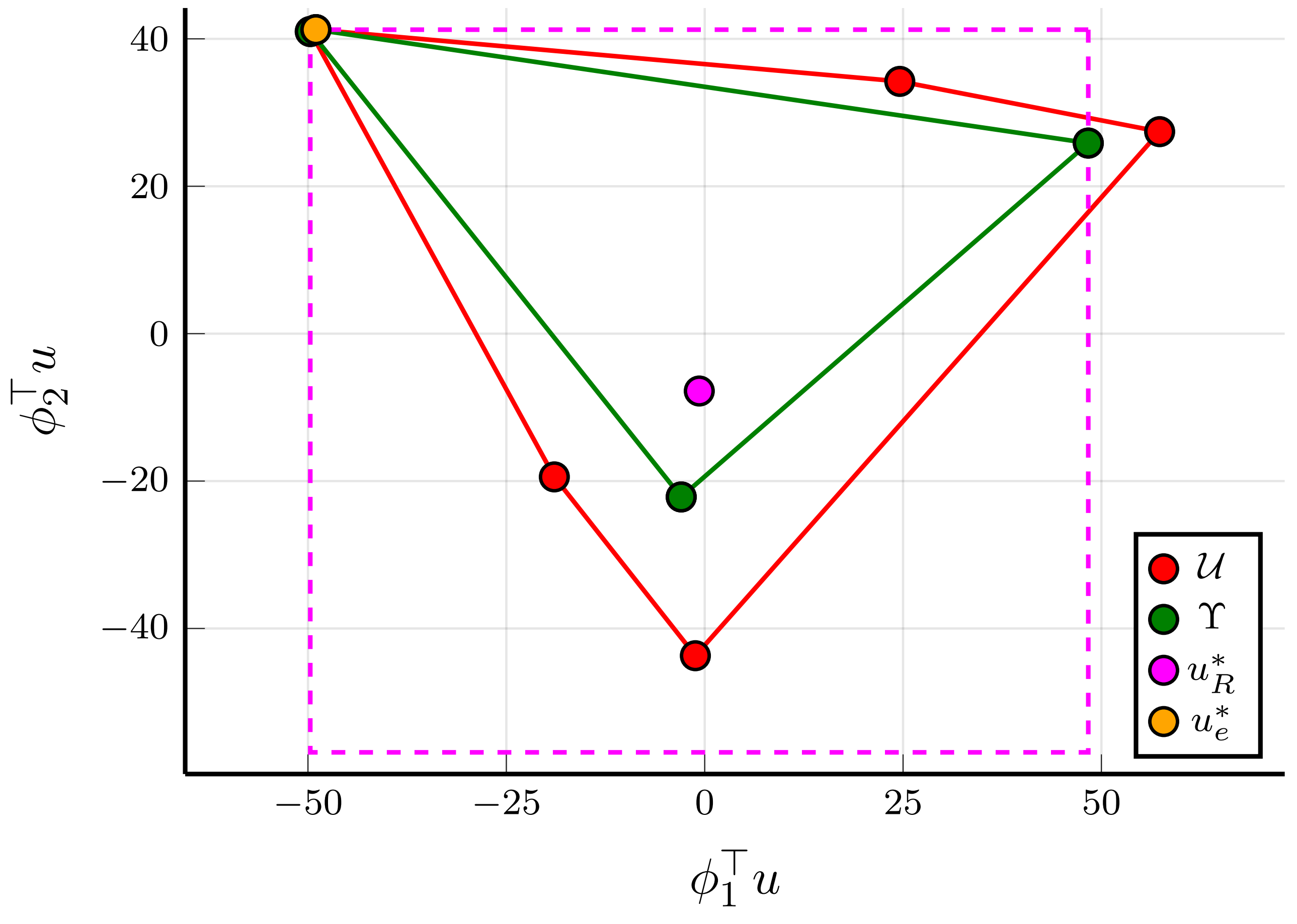
Inverse Reinforcement Learning (IRL)

$$\rho(\pi, r) = \lim_{T\to\infty} \mathbb{E}^{\pi,p_0}[\sum_{t=0}^{T} \gamma^t r(\tilde{s}_t, \pi(\tilde{s}_t))]$$

$$\pi^*_{IRL} = \arg\min_{\pi\in\Pi} \max_{r\in\mathcal{R}} \rho(\hat{\pi}_e, r) - \rho(\pi, r)$$

$$\pi^*_{ROIL} = \arg\min_{\pi\in\Pi} \max_{\pi_e\in\Pi} \max_{r\in\mathcal{R}} \rho(\pi_e, r) - \rho(\pi, r)$$

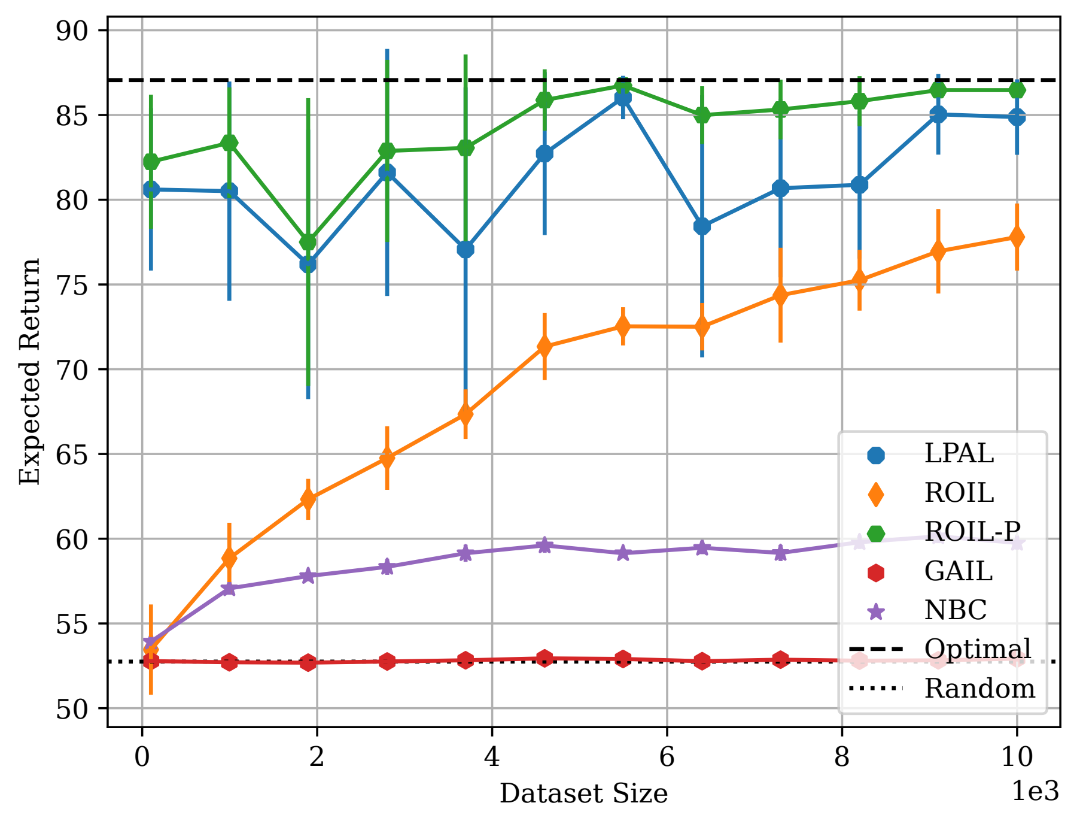
Visual Representation of ROIL

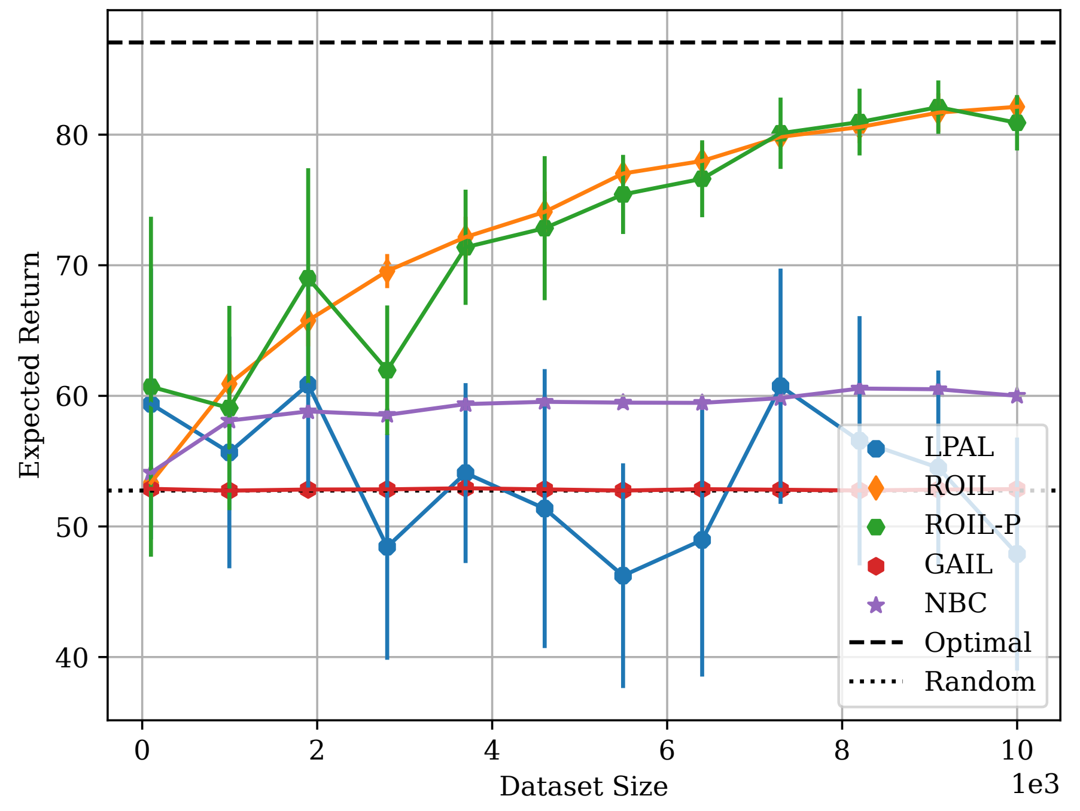


ROIL LP

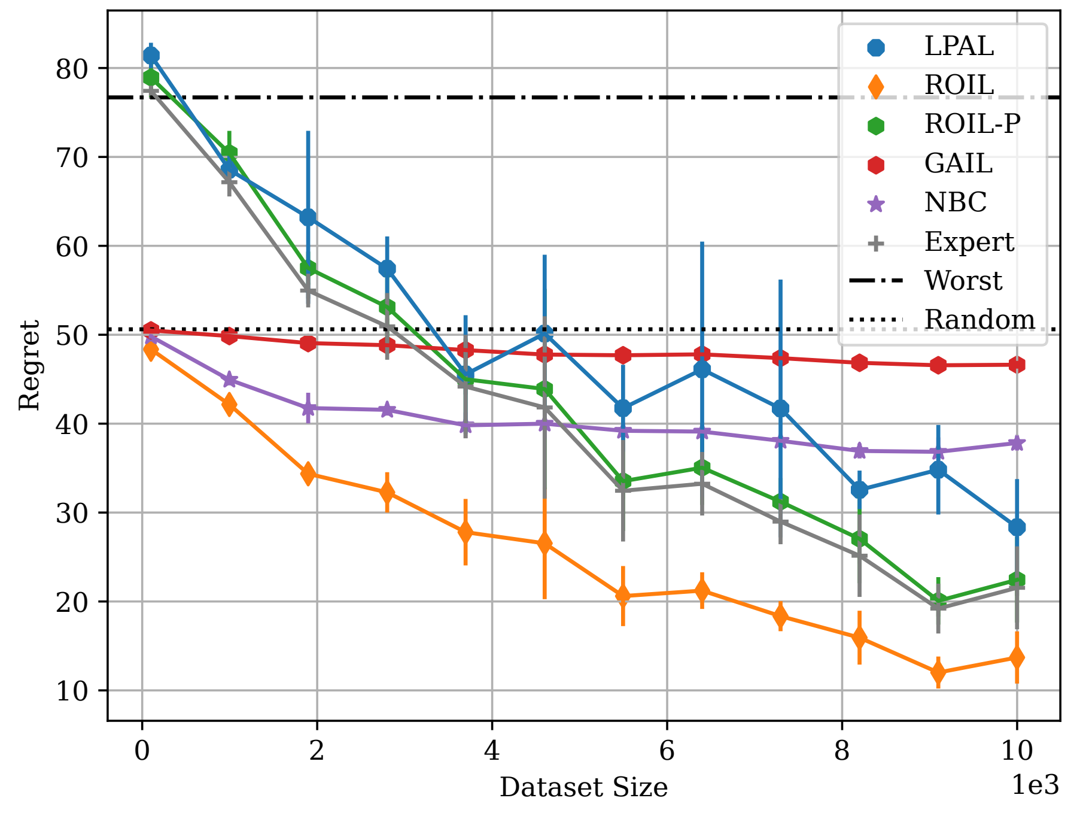
$$\begin{aligned} \min_{t\in\mathbb{R}, u\in\mathbb{R}^{\mathcal{S}\times\mathcal{A}}} \quad & t \\ \text{s.t.} \quad & t \geq -u^\top \Phi w + \max_{v\in\Upsilon} v^\top \Phi w, \quad \forall\, w \in ext(\mathcal{W}), \\ & u \in \Upsilon, \end{aligned}$$

Gridworld Results





Regret Results


Regret
1e3
Dataset Size
LPAL
ROIL
ROIL-P
GAIL
NBC
Expert
Worst
Random