Master Project

High Capacity Model in Data-Driven Inverse Optimization

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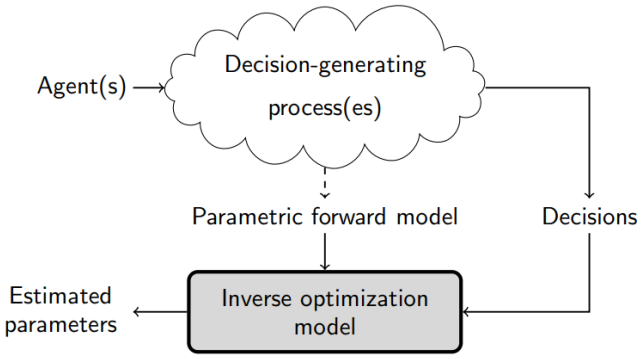
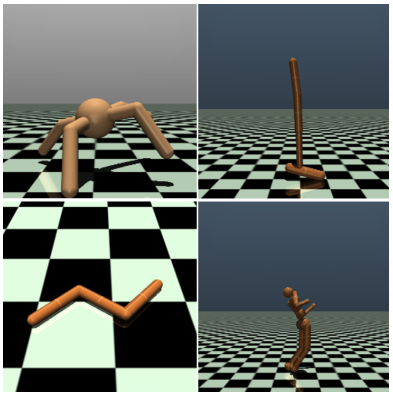
Context

In recent years, there has been an explosion of interest in the mathematics and applications of inverse optimization. For example, it has found diverse applications in areas such as transportation, healthcare, and power systems, where we can use an observed data set of decisions to estimate a decision-making model that best reproduces these observations. In these applications, inverse optimization provides a mathematical framework for estimating latent parameters and subjective preferences within decision-making problems [2].



Specifically, inverse optimization involves selecting a forward model and determining which parameters in the objective function and constraints need to be learned. If the model's capacity is too small, it becomes challenging to learn decision inferences for complex tasks. On the other hand, increasing model capacity often implies more learning parameters, leading to increased demands on storage and computational power. However, the kernel trick ingeniously resolved this dilemma. It increases the model capacity, and recuses computations by inducing inner products. This technique has been successfully applied to machine learning models such as SVM and Gaussian Process Regression.

Project tasks



In this project, we will start from the quadratic model, where the θ is the decision variable and s, u are the states and control action respectively [1, 3]

$$F_\theta(s,u) = \begin{bmatrix} s \\ u \end{bmatrix}^T \theta \begin{bmatrix} s \\ u \end{bmatrix}. \tag{1}$$

Then attempt to increase the model capacity to make it suitable for complex decision-making tasks. OpenAI Gym is an open-source toolkit for developing and comparing reinforcement learning algorithms. It offers standardized environments, a simple API, and flexibility for rapid algorithm testing and development. We will apply this approach in the OpenAI Gym environment.

This master thesis project aims to develop a high capacity but efficient model based on (1) applicable to a wide range of tasks in Mujoco environment. Requirements set on the method are:

1. Investigate date-driven inverse optimization and common methods for enhancement of model capacity in the field of machine learning
2. Draw inspiration from it and apply them to the quadratic model (1)
3. Implement the algorithm in Mujoco tasks

References

[1] Syed Adnan Akhtar, Arman Sharifi Kolarijani, and Peyman Mohajerin Esfahani. "Learning for control: An inverse optimization approach". In: *IEEE Control Systems Letters* 6 (2021), pp. 187–192.

[2] Timothy CY Chan, Rafid Mahmood, and Ian Yihang Zhu. "Inverse optimization: Theory and applications". In: *arXiv preprint arXiv:2109.03920* (2021).

[3] Pedro Zattoni Scroccaro, Bilge Atasoy, and Peyman Mohajerin Esfahani. "Learning in Inverse Optimization: Incenter Cost, Augmented Suboptimality Loss, and Algorithms". In: (2023).