Project proposal for MECH6910M

Mingfei SUN, Computer Science & Engineering, The Hong Kong University of Science and Technology

Project title

Learning human behaviors for non-humanoid robots from motion capture by generative adversarial imitation

Brief description

Imitation Learning is a technique for robots to automatically imitate human behaviors to finish tasks, e.g., to grasp objects or to walk upright. As a recent breakthrough, Generative Adversarial Imitation Learning (GAIL) [1] provides a new possibility for robots to generate human-like movement patterns from demonstrations. In general, GAIL compares state-action pairs from demonstrations against state-action pairs from the policy by a discriminate classifier (discriminator). The imitation policy is assigned rewards for fooling the discriminator. One of the key advantages of GAIL over previously RLfD techniques, i.e., behavior cloning and IRL, is that the similarity between imitation and demonstration is defined implicitly. Studies have demonstrated that the GAIL produces reusable motions for humanoid robots from only a small number of noisy human motion capture demonstrations [2].

Nevertheless, few studies have investigated whether the generative adversarial imitation could be used for planning motions for non-humanoid robots. Different from humanoid robots, non-humanoid robots are structurally different from human body; directly applying the method in [2] would be problematic. For example, it would be challenging to map a human whole-body throwing action to a robotic arm with limited DoFs. Also, mapping motions to robots may also need to keep motion styles so that the motions could be more understandable to humans, e.g., legible motions. In this project, we are interested in investigating a generic algorithm to re-target motion capture to non-humanoid robots, e.g., a robotic arm, while keeping the human-like motion styles. Specifically, we will use the existing motion capture data [1] as human behavior sources. We then train a generative adversarial network to map these behaviors to a robotic arm (Universal Robotics UR10).

Scope of work

Imitation Learning, also called *Robot Learning from Demonstration (RLfD)*, is a technique for robots to automatically learn to perform behaviral tasks from expert demonstrations. This behavior imitation has several advantages. First, it captures the intricacies of humanoid behaviors and thus typically produces visually pleasing, human-like movements for robots. Second, it creates human-like movements suited for reuse and refinement, avoiding repetitions when planning motions and thus facilitating development. Conventionally, two main approaches can be adopted for behavior imitation: behavior cloning (a.k.a, motion re-targeting in computer animation), which learns state-action mappings in a supervised manner from expert trajectories; and Inverse Reinforcement Learning (IRL), which recovers a reward function to find an optimal state-action mapping. However, both approaches are reported to tend to produce non-human-like and overly stereotyped movement behaviors for robots [2]. Also, these approaches may require a great deal of domain knowledge and engineering when planning motions. Generative Adversarial Imitation Learning (GAIL) [1], a recent technique breakthrough for imitation learning, however, opens up new possibilities for robots to automatically generate human-like movement primitives from demonstrations by generative adversarial networks. Studies have also demonstrated promising results when GAIL is extented to motion capture re-targetting.

Research plan

This project is scheduled as follows:

- **Literature review**: Generative Adversarial Imitation Learning. *2018-10-08 to 2018-10-15*
- **Simulation platform development and data collection**: Gazebo or MuJoCo simulation environment with Universal Robotics UR10 robot arm; MoCap data preprocessing. *2018-10-16 to 2018-10-30*
- **GAIL implementation**: Dataset splitting and augmentation; discrimitor construction and training. *2018-11-01 to 2018-11-15*
- **Evaluation**: User study via Amazon Mechanic Turk (AMT). *2018-11-15 to 2018-11-30*
- **Report writing**: Drafting report. *2018-12*

References

[1] J. Ho and S. Ermon, "Generative adversarial imitation learning," in *Advances in Neural Information Processing Systems*, 2016, pp. 4565–4573.

[2] J. Merel, Y. Tassa, S. Srinivasan, J. Lemmon, Z. Wang, G. Wayne, and N. Heess, "Learning human behaviors from motion capture by adversarial imitation," *arXiv preprint arXiv:1707.02201*, 2017.

[1] http://mocap.cs.cmu.edu/