Disentangled Dynamics Learning through Randomized-to-Canonical Visual Translation for Sim-to-Real Robotic Manipulation

Name: Tomoya Yamanokuchi

Laboratory's name: Robot Learning Lab.
Supervisor's name: Takamitsu Matsubara

Abstract

Sim-to-Real transfer has been attracting attention in recent years and the most successful technique is Domain Randomization. While this technique has been successful in model-free approaches, their success in model-based approaches for transferring dynamics models has been limited especially for visual tasks. The main reason may be lack of clear design principles for how task-relevant intrinsic features should be extracted from randomized image.

In this study, we propose a framework for learning visual dynamics models with Visual Domain Randomization with a focus on the extensibility of dynamic models as a design principle. To this end, we propose a novel learning approach with a disentangled structure in which feature extraction and dynamic model are associated but separated for each other. For feature extraction, we utilize Randomized-to-Canonical Visual Translation. This simple structure enables us to extract task-relevant intrinsic features guided by Canonical images. To demonstrate the effectiveness of our method, we provide extended cases for different purposes. In Case 1, the purpose is Sim-to-Real transfer to test domains with no environmental variation, and a general state-space model is used as a dynamic model. The task is to rotate a valve at a constant velocity, and it is confirmed that the Model Predictive Control (MPC) using our model can achieve a zero-shot transfer to real-world test domains with large reality gaps. In Case 2, Sim-to-Real transfer to test domains with environmental variations is targeted, and a state-space model utilizing content-motion separation is used as a dynamic model to capture environmental variation. We evaluated MPC performance in object-pushing task with varying object sizes as an environmental variation. The results confirmed that the proposed model can achieve high task performance by capturing the environmental variation factors.