

Sim-to-real transfer via a Style-Identified Cycle Consistent Generative Adversarial Network: Zero-shot deployment on robotic manipulators through visual domain adaptation

A.J. López López; J. Boal Martín-Larrauri; L. Güitta López

Abstract-

The sample efficiency challenge in Deep Reinforcement Learning (DRL) compromises its industrial adoption due to the high cost and time demands of real-world training. Virtual environments offer a cost-effective alternative for training DRL agents, but the transfer of learned policies to real setups is hindered by the sim-to-real gap. Achieving zero-shot transfer, where agents perform directly in real environments without additional tuning, is particularly desirable for its efficiency and practical value. This work proposes a novel domain adaptation approach relying on a Style-Identified Cycle Consistent Generative Adversarial Network (StyleID-CycleGAN or SICGAN), an original Cycle Consistent Generative Adversarial Network (CycleGAN) based model. SICGAN translates raw virtual observations into real-synthetic images, creating a hybrid domain for training DRL agents that combines virtual dynamics with real-like visual inputs. Following virtual training, the agent can be directly deployed, bypassing the need for real-world training. The pipeline is validated with two distinct industrial robots in the approaching phase of a pick-and-place operation. In virtual environments agents achieve success rates of 90 to 100%, and real-world deployment confirms robust zero-shot transfer (i.e., without additional training in the physical environment) with accuracies above 95% for most workspace regions. We use augmented reality targets to improve the evaluation process efficiency, and experimentally demonstrate that the agent successfully generalizes to real objects of varying colors and shapes, including LEGO® cubes and a mug. These results establish the proposed pipeline as an efficient, scalable solution to the sim-to-real problem.

Index Terms- Transfer learning; Deep reinforcement learning; Domain adaptation; Sim-to-real; Zero-shot

Due to copyright restriction we cannot distribute this content on the web. However, clicking on the next link, authors will be able to distribute to you the full version of the paper:

[Request full paper to the authors](#)

If your institution has a electronic subscription to Engineering Applications of Artificial Intelligence, you can download the paper from the journal website:

Citation:

Boal, J.; Güitta-López, L.; López López, A.J. "Sim-to-real transfer via a Style-Identified Cycle Consistent Generative Adversarial Network: Zero-shot deployment on robotic manipulators through visual domain adaptation", Engineering Applications of Artificial Intelligence, vol.159, no.Part A, pp.111510-1-111510-15, November, 2025.