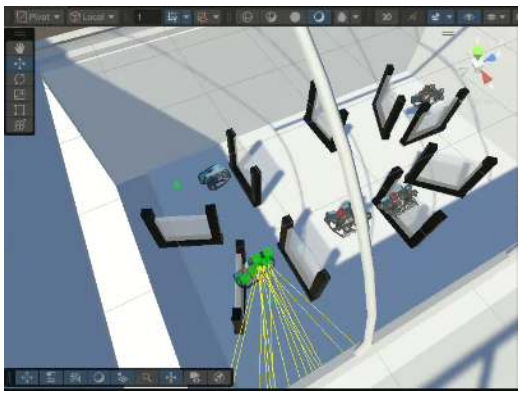
Crossing the Sim-to-Real Gap in Reinforcement Learning for Autonomous Underwater Vehicles





Recent advances in reinforcement learning (RL) have produced control policies that match or outperform expert humans in highly dynamic vehicle control tasks, both in simulated racing [1] and in real-world drone racing [2]. However, the control of underwater vehicles remains comparatively underexplored, largely because of the difficulty of transferring **policies trained in simulation to real autonomous underwater vehicles** (AUVs). Perception is severely degraded underwater, hydrodynamic effects are expensive and inaccurate to model, and controllers must remain robust to large model uncertainty at high speeds. Only very recently have zero-shot sim-to-real RL controllers been demonstrated on real underwater platforms [3, 4].

The goal of this project is to **characterize and reduce the sim-to-real gap** for learned AUV controllers. The student will start by implementing a training **pipeline for reinforcement learning** agents in an existing realistic underwater robotics simulator, together with a dynamics model of the target vehicle. Subsequently, the student will investigate **methods for closing the sim-to-real gap** (such as system identification of the vehicle dynamics, domain randomization, observation and actuation noise modelling, and adaptive or residual policies) and quantify how each affects the discrepancy between simulated and real behaviour. Finally, **the student will deploy and evaluate the resulting policies on a real AUV platform available at KTH, comparing them against standard control-based baselines and using the collected real-world data to iterate on the simulator and the training pipeline.**

Required qualifications: proficiency in Machine Learning and Robotics. This project targets students in Computer Science, Machine Learning or Robotics. Applicants are expected to have passed KTH courses such as DD2421 Machine Learning, DD2424 Deep Learning in Data Science, EL2805 Reinforcement Learning, DD2410 Introduction to Robotics or equivalent. Confidence in Python, C++ and deep learning frameworks like PyTorch, TensorFlow or Jax is

required. Experience with ROS, robotics simulators (e.g., Unity, Gazebo, Isaac Sim) and previous hands-on work with real robotic platforms, including field or pool trials, is a strong merit.

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References:

- [1] – Wurman, Peter R., et al. "Outracing champion Gran Turismo drivers with deep reinforcement learning." Nature 602.7896 (2022): 223–228.
- [2] – Kaufmann, Elia, et al. "Champion-level drone racing using deep reinforcement learning." Nature 620.7976 (2023): 982–987.
- [3] – Fosso, Lauritz Rismark, et al. "Sim2Swim: Zero-Shot Velocity Control for Agile AUV Maneuvering in 3 Minutes." arXiv preprint arXiv:2512.08656 (2025).
- [4] – Sufán, Vicente, and Giancarlo Troni. "Swim4real: deep reinforcement learning-based energy-efficient and agile 6-dof control for underwater vehicles." IEEE Robotics and Automation Letters 10.7 (2025): 7326-7333.