# RL-based safe navigation using depth images

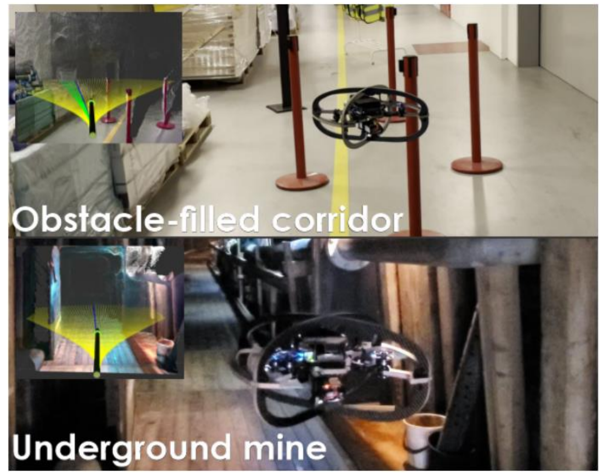


*Figure 1: Examples of a robot with 2D action sequences in environments*

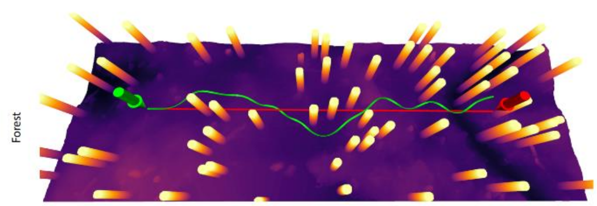


*Figure 2: Drone navigating a forest using a learning-based method to predict trajectories [3].*

**Abstract:**

Exploiting aerial robots in unknown complex environment requires using onboard sensors, such as lidars or depth cameras, to generate safe motions which account for observed obstacles. However, the analytical evaluation of safety of all possible trajectories cannot be performed. Pre-sampled motion primitive libraries can be used to reduce the number of trajectories to evaluate, but the problem is still too complex to solve analytically, since it relies on building an accurate volumetric map of the environment from sensor data.

This project and thesis aim to investigate the use of reinforcement learning (RL) to tackle the problem of collision-free navigation to predict control-action sequences or trajectories. While supervised learning has been leveraged to evaluate a safety criterion on pre-sampled trajectories directly exploiting the sensor data, it requires a labeling process which can be cumbersome and limits the generalization of the learned policy. On the other hand, RL has been widely employed toward safe navigation over the past few years and seems to provide better generalization capabilities and a smaller sim-to-real gap.

**Tasks:**

- Survey RL-based methods for collision-free navigation
- Become familiarized with deep learning and simulation tools
- Propose and implement a RL method to address this problem
- Benchmark such method with some supervised-learning counterparts and evaluate their pros and cons
- Evaluate proposed methods on simulated robots and test them on a real GPU-equipped drone.

**Literature (indicative):**

[1] Charles Richter and Nicholas Roy. “Safe Visual Navigation via Deep Learning and Novelty Detection”. In: Robotics: Science and Systems XIII (2017). https://doi.org/10.15607/RSS.2017.XIII.064

[2] David Hoeller, Lorenz Wellhausen, Farbod Farshidian, Marco Hutter. "Learning a State Representation and Navigation in Cluttered and Dynamic Environments". In: IEEE Robotics and Automation Letters 6.3 (2021). https://doi.org/10.1109/LRA.2021.3068639

[3] Antonio Loquercio, Elia Kaufmann, René Ranftl, Matthias Müller, Vladlen Koltun, and Davide Scaramuzza. "Learning high-speed flight in the wild". In: Science Robotics 6.59 (2021). https://doi.org/10.1126/scirobotics.abg5810

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[5] Huan Nguyen, Sondre Holm Fyhn, Paolo De Petris, Kostas Alexis. "Motion Primitives-based Navigation Planning using Deep Collision Prediction". In: IEEE Int. Conf. on Robotics and Automation (2022). https://doi.org/10.1109/ICRA46639.2022.9812231

**Relevant Project Information:**

- **Digiforest Project & RESNAV Project – Funding Agencies: European Commission, AFOSR**

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