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SELF-SUPERVISED LEARNING AS AN ENABLING TECHNOLOGY FOR FUTURE SPACE EXPLORATION ROBOTS: ISS EXPERIMENTS

Abstract

Future space missions will increasingly rely on the help of robotic systems and in some cases even be performed purely by fully autonomous robots.

Currently, robots lack the ability to learn from their environment. Learning is advantageous, since it decreases engineering effort and allows the robot to adapt to specific properties of its potentially yet unknown environment. However, in space robotics machine learning is not yet used, as it introduces extra risk for safety-critical missions.

In this talk, we will introduce self-supervised learning as a reliable learning method that allows robots to adapt to their environment. We have previously successfully tested this method for the navigation of autonomous drones on Earth, which showed its potential in terms of reliability for application in space. Here, we will present preliminary results from an ISS test performed with the MIT/NASA SPHERES VERTIGO satellite, which is equipped with a stereo vision system that allows it to see distances and navigate by itself in the ISS.

The presented preliminary experiments were performed on October 8th 2015 on board the ISS. In the experiments, the satellite learned by itself how to see distances with a single camera. It did so by using the distance estimates from its stereo vision process as supervised learning targets. The main advantage of this learning method is that the robot becomes robust against losing the images from one of the cameras - it can then still continue to function.

The main goals of the experiment were (1) data gathering, and (2) navigation on the basis of stereo vision. First the astronaut Kimya Yui moved the satellite around the Japanese Experiment Module to gather stereo vision data for learning. Subsequently, the satellite freely explored the space in the module based on its (trusted) stereo vision system and a pre-programmed exploration behavior, while simultaneously performing the self-supervised learning on board in the background.

The two main goals were successfully achieved, representing the first online learning robot experiments in space. These results lay the ideal basis for a follow-up experiment in which the satellite will use the learned single-camera distance estimation for autonomous exploration in the ISS, and form a small step towards future space robots that continuously improve their navigation capabilities over time, even in harsh and completely unknown space environments.