Evaluating a Simulation Setup for Testing the Safe Behavior of UAVs

Master Thesis

Supervisor: Prof. Dr. Alexander Pretschner
Advisor: Tabea Schmidt
Email: {alexander.pretschner, tabea.schmidt}@tum.de
Phone: +49 (89) 289 - 17834
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Fakultät für Informatik
Lehrstuhl 4
Software & Systems Engineering
Prof. Dr. Alexander Pretschner

Boltzmannstraße 3
85748 Garching bei München

Tel: +49 (89) 289 - 17834
https://www4.in.tum.de

Context

Unmanned Aerial Vehicles (UAVs) are operated in different use cases, such as transporting packages or monitoring an area. In the near future, UAVs will perform their missions completely autonomously. We, thus, need to ensure that these systems behave safely and do not harm anybody or anything while operating. One way of testing this safe behavior of UAVs is simulation-based testing, where a model of the UAV is tested in a simulation environment. There exist various UAV models and simulation platforms to execute this testing. When testing the safe behavior of autonomous systems, scenario-based testing [1, 2] is often used. In this approach, the UAV is tested in typical situations that it might encounter, e.g., transporting a package to a destination point while encountering two static obstacles. These so-called logical scenarios can be represented by the simulation environment and mission of the UAV. For assessing the safe behavior of the UAV, it is posed in the given simulation environment and provided with the specified mission. In the next step, our goal is to generate "good" test cases for each logical scenario that can reveal potential faults in the UAVs. For this purpose, we use search-based techniques [3] to search for these "good" test cases.
At our chair, we built a framework for generating "good" test cases for testing the safe behavior of UAVs in several logical scenarios that uses Gazebo [4] as a simulation environment for testing the safe behavior of the open-source flight control system PX4 [5].

Goal

The goal of this thesis is to evaluate the applicability of our proposed methodology for testing the safe behavior of UAVs to a new simulation environment and UAV model, e.g., the Paparazzi UAV model [6]. In a first step, existing simulation environments and UAV models in the literature are explored. After selecting the best fitting ones, the new simulation environment and the model are set up, and an easily extendable framework for generating "good" test cases for UAVs is implemented. Finally, the usefulness and applicability of different features are investigated to derive a good assessment of the technical capabilities of the proposed simulation environment and UAV model.

Working Plan

1. Familiarize yourself with the idea of testing the safe behavior of UAVs with scenario-based testing and search-based techniques as well as with the provided simulation framework that uses Gazebo and the flight control system PX4.
2. Investigate different UAV models and simulation environments in the literature and discuss their advantages and shortcomings.
3. Setup the new simulation environment and UAV model and implement a framework for generating "good" test cases for a simple logical scenario.
4. Investigate the different features that can be implemented/executed with the new setup, including various logical scenarios, environment settings, failure modes of the UAV, and cooperation of UAVs.
5. Record your literature results, design decisions, implementation, and application results in form of a thesis.

Deliverables

- Source code of the implementation.
- Technical report with comprehensive documentation of the implementation, i.e., design decision, architecture description, API description, and usage instructions.
- Final thesis report written in conformance with TUM guidelines.

Application for Thesis

Please apply for this thesis topic with your CV, grade report, and a short motivation, why you are interested in this topic. Based on these documents, we will invite some students for a personal meeting to see if the topic fits the student.

Please note that the student working on this thesis needs to have access to a Linux-based operating system (provided framework works on Ubuntu 18.04) to execute the simulation environment.

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References

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