Using Randomly Generated Digital Twins for Validating Embedded Software Systems

Graduate

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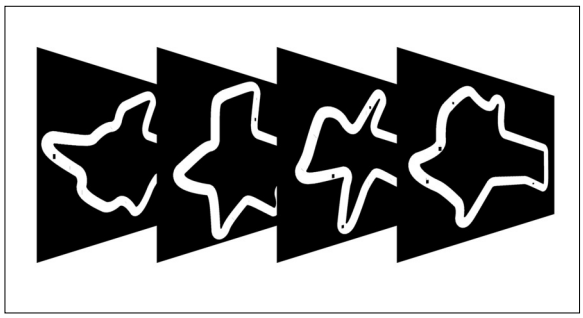
Introduction: Developing and validating embedded software can be very difficult and demanding, as the system boundaries are usually open. Software systems for autonomous driving are particularly critical. It is essential that their behaviour is tested in all kinds of scenarios to guarantee safe behaviour.

The authors of this work evaluate whether the software validation process can be facilitated using digital twins. A digital twin is a computer simulation of all relevant parts of the physical world that are linked to the software components being tested. The goal of this digital twin approach is to evaluate software quality faster and in a more versatile way compared to real-world testing.

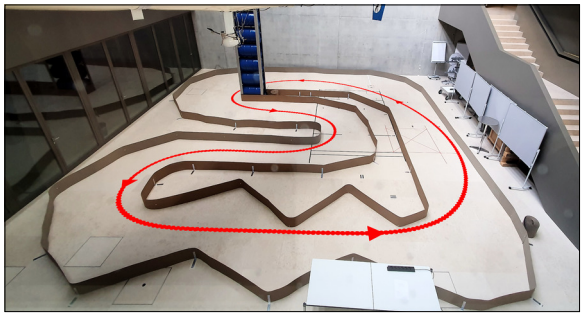
Approach: As a technological basis for this work the authors selected the F1TENTH platform. It consists of a physical 1:10 scaled race car equipped with a LiDAR distance sensor and an inertial measurement unit (IMU). Different F1TENTH student teams create software stacks for autonomous driving, which may also include a simulation component. The ForzaETH race stack was chosen for evaluation with the digital twin approach. To validate the stability and performance of this existing race stack, the authors created a fully automated test environment that allows for high-throughput testing with randomly generated tracks including obstacles.

Conclusion: Thanks to this automated testing process, various scenarios have been identified in which the race stack does not behave as expected and still has potential for improvement. The behaviour of the system in the simulation was reproduced and verified by testing it with the physical car. Although there were a few pitfalls with the physical car, it has been shown that a digital twin is a powerful tool in the software validation process, making it less time consuming and allowing the developers to test much more situations that might not have been considered in a physical test environment.

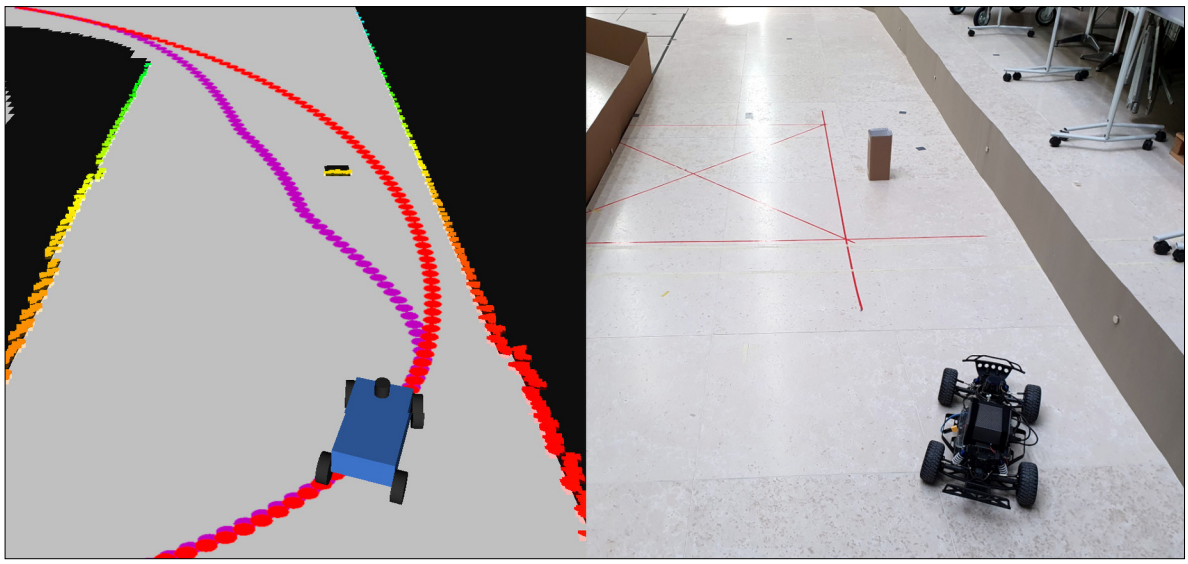
Some of the randomly generated tracks.
Own presentment



Race track used for physical validation of the system with an overlay of the optimal trajectory.
Own presentment



Comparison between the simulation and the real setup. Optimal trajectory in red, obstacle avoiding trajectory in purple.
Own presentment



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Subject Area
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