Chapter 29
UFO: Ultraflat Overrunable Robot for Experimental ADAS Testing

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29.1 Introduction

Our method, which was developed over the last years with increasing importance, is the application of autonomously driving platforms, called “UFOs” (cp. Fig. 29.1) [1], which are GPS controlled. They form the high-end motion platforms for different targets, as they allow full 2D motion, independent of the infrastructure. No adaptation of the infrastructure is necessary. The top speed is currently limited to 80 km/h.

These UFOs are designed in a way that the height of the platform is lower than the height of the ground plate of the vehicle under test (VUT). Even in case of a collision, no damage is caused to the VUT or the platform itself. In addition they are surrounded by ramps, which allow a smooth overrun of the platform by the VUT, even at high speeds.

29.2 Structure of the UFO Platform

The internal structure of an UFO is depicted in Fig. 29.2. It consists of several subsystems which are described in the upcoming section.

The propulsion system of the platform typically consists out of one or two electric motors. Their power depends on the required performance of the platform. Typical power of the whole drivetrain is 5–15 kW. Mostly the electric motor is used...
for braking. Nevertheless, as decelerations up to 0.7 g are requested, the platform also includes a hydraulic braking system.

The energy supply is provided by Li-ion batteries, which are provided as exchangeable packs.

As navigation system, high-performance differential GPS (DGPS) is used. It combines DGPS-corrected satellite signals with inertia systems, using a Kalman filter. To control the platform, only systems providing this real-time synchronization of inertia system and DGPS can be used to archive the precision necessary for complex test scenarios. Position and heading, the two main controlling parameters, can be derived with a typical accuracy of ±5 cm.
As DGPS systems cannot be used indoor, it currently limits the system to outdoor use. At the moment, there are alternative navigation systems in evaluation, which can also be used indoor.

Using WLAN communication between car, platform, and base station, the timing and the target information is transmitted to the platform. In this way, the platform can also be attached to the VUT using a master-slave relation. The steering algorithm of the control system will calculate the necessary parameters to follow the target path.

Based on these systems, the control system inside the platform derives the signals for steering and engine control/brake by comparing target and real position. When the navigation signal is temporarily missing, the inertia platform can extrapolate the missing positions. The inertial system also reduces the noise of the DGPS signal with respect to the heading information.

There are two ways to steer the platform: either there are one or two wheels which are rotated by a steering servo to drive the platform along the target path.

To simulate, e.g., pedestrian movement, allowing also on spot rotation, steering control can also be performed by prescribing different velocities to the left and right wheels/chains. In this way, the platform can also rotate on the spot.

### 29.3 Communication Infrastructure

Figure 29.3 shows a typical communication setup to allow all kinds of necessary information transfer:

As basis for the communication, wireless modules (Wi-Fi) are used, running on 2.4 and 5 GHz. For the DGPS correction signal, 434/868 MHz frequencies are used.

As Wi-Fi is not intended to run real-time applications, every message must imply universal time codes, generated by time synchronous clocks included in every unit. The synchronization is guaranteed by using GPS time in every unit.

The Central Control Unit (CCU) is dedicated to control all devices, involved in the test setup. As also multiple vehicles or platforms may be involved in one scenario, this CCU has to provide this functionality. Within this CCU, the individual paths of the controlled vehicles and platforms are generated. The may be generated either within GPS coordinates or also relative to the VUT. In this way, the VUT can also act as a master controlling the platforms as his slaves. As an alternative, all involved partners can also run according to fixed paths with a fixed timing.

When the VUT acts as master, there are different methods to control the platforms:

The simple method is using a light gate triggering the start of the platforms. In this way, the platforms are following predefined paths, but their start is triggered by the light gate. Typically timing and velocity of the VUT are measured simultaneously for an optimum performance to allow more accurate testing, when the VUT is driven manually.
As an alternative, the VUT can also be equipped by a DGPS, which reports the position, velocity, and direction of the VUT to the base station. Based on this information, the velocity and path of the platforms may be adapted in real time. The advantage of this method is a very high degree of accuracy and flexibility. The disadvantage is that the VUT must be equipped with a DGPS and communication module. The integration of this equipment into the VUT requires typically 20 min setup time.

### 29.4 Definition of Test Scenarios

Typically these platforms can be used in infinite number of scenarios. These situations are either driving scenarios like priority violation, turning left, overtaking, or lane changes or parking scenarios. Many additional scenarios are derived from the evaluation of accident databases, where scenarios with repeated accident potentials and accident occurrence are mainly used for evaluation. In addition, critical driving scenarios from normal driving are repeated [3].

Out of these accidents, specific scenarios are derived and typically varied to ensure the functionality of the system not only in one exact scenario but in a set
of scenarios with similar characteristics. Various different databases are currently in use to develop these scenarios. One of the most commonly used accident databases is the GIDAS [2] database which is handled by the Medical University of Hannover and the Technical University of Dresden. They collect more than 2000 accident cases per year, where a special accident evaluation team goes on site at the accident scene in selected areas. The selection criterion for the accidents, added to the database, is the occurrence of at least one injured person.

Based on the evaluation of this database, critical scenarios and their possible evaluations are derived. These scenarios are also used to define the boundary conditions and criteria for the sensor systems and algorithms.

After reconstruction of the accident, a set of reference scenarios is derived and can be exported to the platforms and steering robots. It can be rerun on a selected test area. The environment can either be neglected or represented by selected stationary obstacles (Fig. 29.4).

29.5 Summary

This paper presents an overview of the UFO test platform. Currently it is primarily used to reconstruct accidents. Additionally it can be utilized to evaluate ADAS functions. In the future, it could also be used for testing autonomous driving functions.
References

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3. Schmidl, ADAS Testing with the UFO Testing System, in Autonomous Vehicle Test & Development Symposium, Stuttgart, 2015