Developing an autonomous racing vehicle for Formula Student Driverless

Track Record

Precise, reproducible, adaptive – these are the prominent characteristics of virtual drivers. The Formula Student team of Augsburg University of Applied Sciences is focusing its efforts on precisely this to achieve the best possible lap times. It uses a MicroAutoBox and RTMaps, a multisensor development environment, for developing the autonomous driving control.

Formula Student is always up to date, even for the latest developments in the automotive industry. Since 2017, teams have been competing in Formula Student Driverless with autonomous racing cars. The aim is to race a vehicle around a track marked by traffic cones - as fast as possible and fully autonomously. Team Starkstrom of the Augsburg University of Applied Sciences is one of the participants. The team introduced automated testing with a virtual, GPS-based driver as early as 2015. Chairman Julian Stähler says: “This way, we were able to optimally tune the torque vectoring of our electric vehicle, because no real driver can offer this precise reproducibility.”

Driving by Maps

The team now has an autonomous racing vehicle that complies with regulations and features two lidar sensors and a camera. Thanks to these features, the vehicle can independently capture it and then use GPS to drive around the track at high velocity. Because of the properties of the sensors used, the vehicle start is intentionally slow. For example, the lidar sensor only returns reliable measurement data for speeds up to 20 km/h. At this speed, the racing vehicle first becomes familiar with the track and enters all detected traffic cones and their GPS positions into a map. During this, the camera is responsible for the basic detection and the lidar sensors return the exact distances to the vehicle. During the next lap, the speed is increased and the vehicle is controlled by fused sensor data along the nominal path. The map receives more and more details with each lap. After ten completed laps, the vehicle must stop at the finish line, which the camera must detect on the basis of traffic cones with a different color.

Central Computation Unit

To centrally control the vehicle, the

> “RTMaps and MicroAutoBox help us develop new functions very quickly and implement them in the autonomous vehicle in a short amount of time.”
>
> *Julian Stähler, Team Starkstrom*

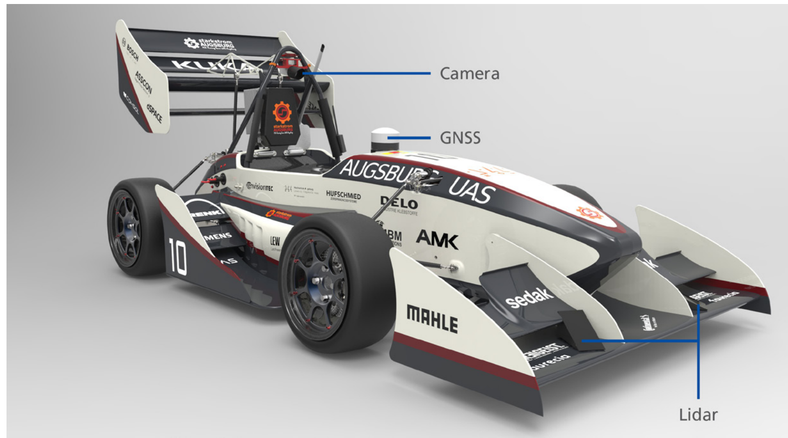
team uses a combination of MicroAutoBox and MicroAutoBox Embedded PC. While MicroAutoBox calculates the steering angle and brake commands, which control the actuators, Embedded PC receives the signals of all image sensors. To process and merge these, the team uses the RTMaps development environment from Intempora.

Developing Algorithms

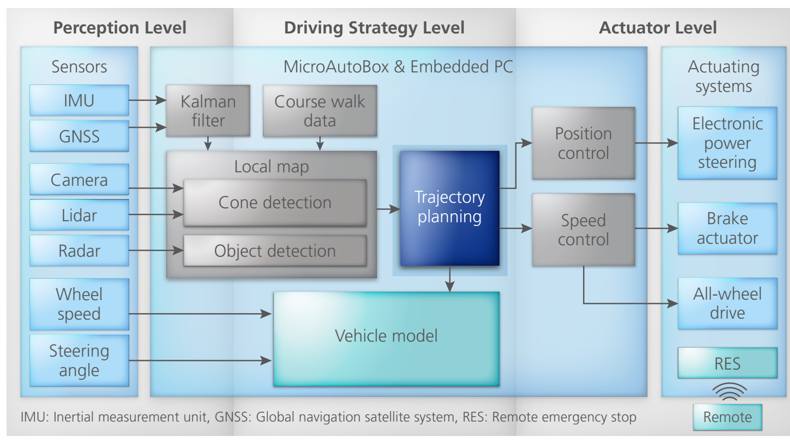
Software developer Mathias Pechinger explains: "We created the algorithms used to detect the traffic cones ourselves using Python and open-source libraries. We then integrated them in RTMaps with the Python block." Afterwards, the camera and lidar signals were fused in RTMaps and the movement trajectories were calculated. After the function development, a simulation was performed, and subsequently it was possible to execute the software immediately on the Embedded PC together with an RTMaps runtime environment. When the vehicle drives autonomously at high speeds, a sensor fusion of GPS reference signal data, lidar data, acceleration and wheel speed is performed. If the GPS signal is disrupted, a Kalman filter supports driving at 50 km/h for another 7 seconds approximately until the vehicle is slowed down and the imaging systems control the vehicle.

Reaching High Performance

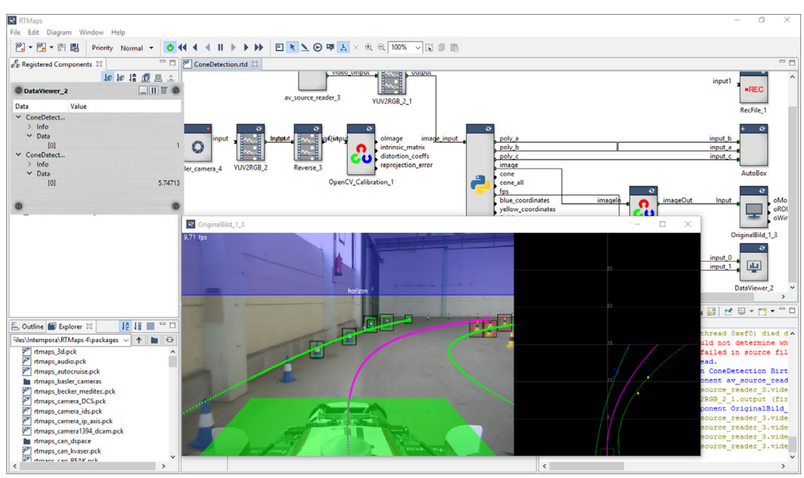
The student developers are extremely content with the functioning and the workflows of RTMaps. Mathias Pechinger says: "RTMaps works really well. Especially the simple linking to the algorithms developed in Simulink® on the MicroAutoBox allows us to implement new functions very quickly." Replacing the initially USB-based camera with an Ethernet-connected model was done just as quickly. The student developers only had to select the relevant RTMaps block for the camera to start working. The flexible and powerful tool chain enabled the team to drastically increase the performance of the vehicle. It can now follow the track safely at 90 km/h, which is a great basis for future competitions.



The autonomous vehicle by the Augsburg University of Applied Sciences is equipped with a global navigation satellite system (GNSS) and captures its environment by using a camera and two lidar sensors.



Schematic setup of the vehicle control.



RTMaps evaluates the captured environment and determines the movement trajectories.