Developing a Self-Driving Vehicle

No Driver Required

Thanks to advances in the development of intelligent drive technology, the time is coming closer when self-driving vehicles will be a part of everyday road traffic. With the help of dSPACE MicroAutoBox, a group of researchers at School of Automotive Studies, Tongji University, China, developed an electric prototype vehicle that can already drive by itself on the university campus.

A vision that is closer to becoming a reality: Self-driving vehicles in everyday traffic

Vehicle Control via MicroAutoBox

The electric prototype vehicle developed by the research team at Tongji University is based on four wheel hub motors with a 140-volt lithium battery. The vehicle handles all sorts of driver assistance functions, including lane keeping and lane changing, adaptive cruise control (ACC), emergency braking, stopping at a stop line, and merging into the traffic flow. MATLAB®/Simulink® is used to develop the functions of the subsystems and two MicroAutoBoxes are used as the control centers of the vehicle.

Combining Several Environment Sensors

To detect the surroundings in detail, the prototype vehicle uses four different types of sensors: namely, camera, GPS, laser radar (lidar), and millimeter wave radar.
The camera and GPS are used to identify the road. To recognize the roadway, the camera detects the side lines of the road. If the road does not have any side line markings, the lane can also be generated with the help of GPS. Lidar and millimeter wave
radar are used to identify the relative positions and relative speeds between the vehicle and obstacles or other vehicles. This information serves as the essential basis for a number of driver assistance functions such as adaptive cruise control (ACC), where the vehicle always maintains a safe distance to the vehicle ahead.

The vehicle prototype designed by Tongji University can already drive on its own around the university campus.

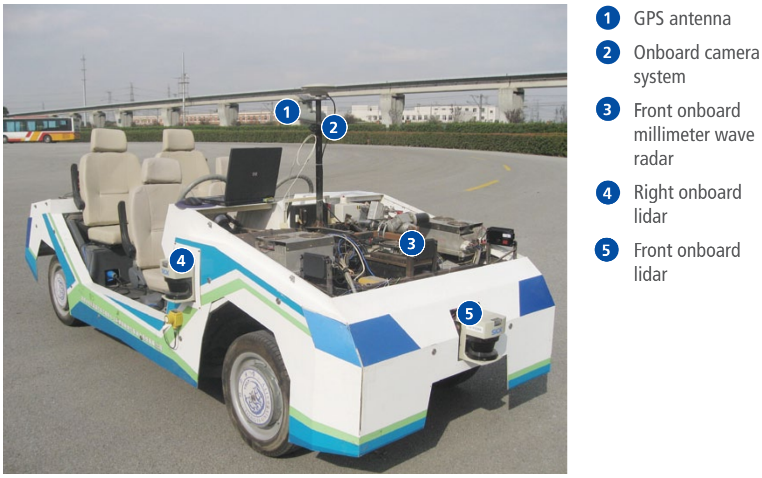


Figure 1: For orientation, the prototype vehicle uses GPS, camera, laser radar (lidar) and a millimeter wave radar.

Two-Stage Path Planning

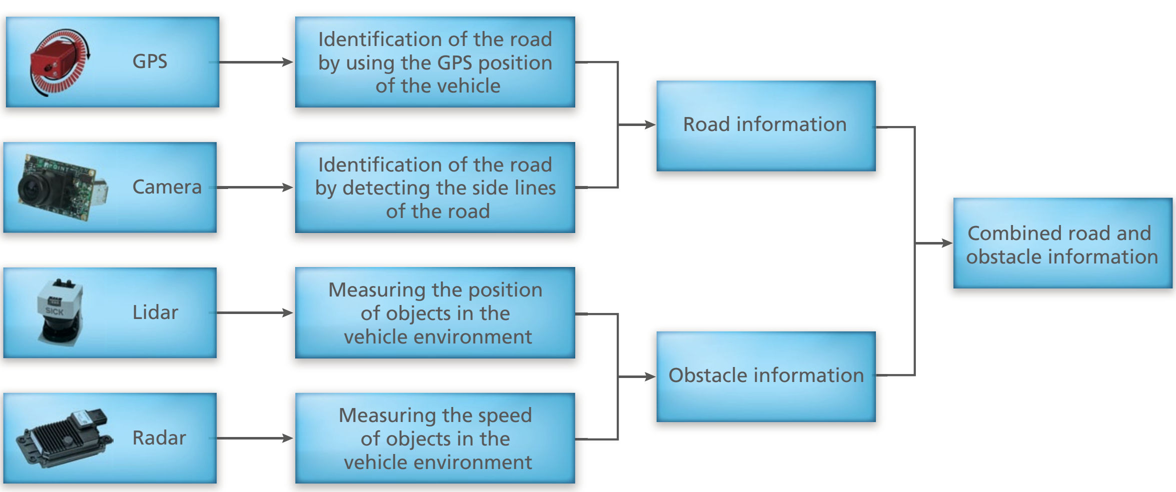
The route is planned in two stages: The first stage is global path planning. This involves using a digital map and the vehicle's current position data to calculate the shortest route from start to finish. The second stage is local path planning. This involves dividing the previously planned global route into short segments. The segments are calculated by cubic spline functions in such a way that the ends of the splines flow into one another. This is used to keep the steering system from suddenly jerking at the interpolation points of the segments. The local path planning outputs the actual steering angle and the speed commands for the vehicle.

Two MicroAutoBoxes in Use

The control algorithms were developed entirely in MATLAB®/Simulink®, so using dSPACE development tools was a natural choice because they are an optimal fit for the MATLAB/Simulink development environment. A particular advantage of the MicroAutoBox is its compact and robust design, which makes it ideal for use in prototype vehicles.
The model, which was designed in Simulink, is automatically coded and implemented on the MicroAutoBox. And the large number of interfaces and driver modules provided by MicroAutoBox simplify every implementation work step. Installation of driver modules in the Simulink model via drag & drop is just one typical example of this convenient work method. On the whole, the dSPACE development environment significantly simplifies several steps, which saves a great deal of development time. The first of the two MicroAutoBoxes collects all the im-

> "Thanks to its robustness and easy configurability, MicroAutoBox is the optimal tool to use in prototype vehicles."
>
> *Prof. Hui Chen, Tongji University*

Figure 2: The road is identified by the camera and/or GPS. Lidar and radar sensors give the vehicle information on the surrounding traffic.



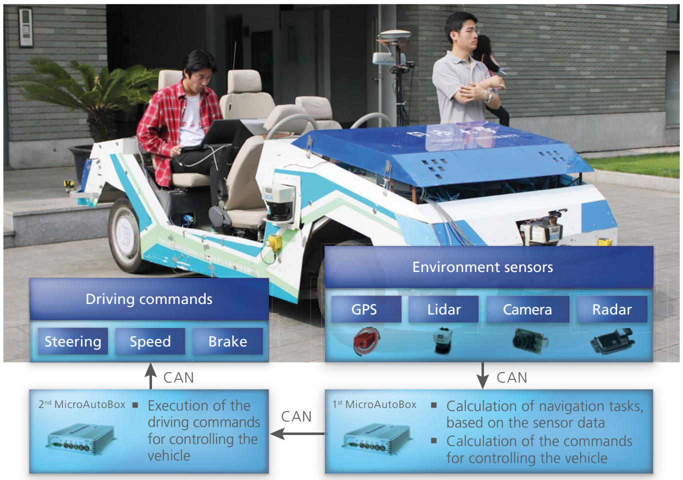


Figure 3: Two MicroAutoBoxes are used in the vehicle. The first MicroAutoBox evaluates the sensor data and calculates the navigation data. The second MicroAutoBox is used to actually control the vehicle (steering, braking, etc.).

portant navigation-relevant data that the various sensors deliver regarding the vehicle environment and uses this data to calculate the commands necessary for controlling the vehicle. The second MicroAutoBox receives these commands via CAN bus and then performs the actual vehicle control (steering, braking, etc.). If necessary, the driver can still take over control of the vehicle at any time by grabbing the steering wheel. In addition, the motor can be switched off automatically for safety reasons.

Autonomous Trips on Campus

The test vehicle is capable of steering around obstacles, such as a pedestrian or another vehicle, while driving on the test route around campus. With the help of a digital map, the vehicle also safely masters stopping at stop lines and cornering. If another vehicle is driving ahead slowly, the test vehicle is also able to follow automatically at a safe distance.

More Sensors in the Future

The next stages of the project will focus on the vehicle's environment detection system because all kinds of autonomous driving technologies are based on this. Moreover, as sensor technology becomes more advanced, the spectrum of automotive sensors that can be used at an acceptable price will also increase. Therefore, future research activities will focus on combining the measurement data from the various sensors and increasing the fault tolerance of the vehicle control. The dSPACE development environment will also be used for these future stages. ■

Prof. Hui Chen,
Tongji University

> "With MicroAutoBox, we can experience new driver assistance functions in the test vehicle immediately."
>
> *Prof. Hui Chen, Tongji University*

Summary

The electric vehicle prototype developed by Tongji University handles various driver assistance functions such as adaptive cruise control, automatic lane keeping and lane changing, stopping at stop lines, and emergency braking. Two MicroAutoBoxes are used in the vehicle. The first MicroAutoBox evaluates the data from the environment sensors (GPS, lidar, radar, camera) and plans the route, the second MicroAutoBox acts as the driver and controls the vehicle.
This makes the vehicle able to drive autonomously on the university campus.

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