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Highly Automated Driver Assistance Systems for Offroad Scenarios

Unmanned ground vehicles (UGVs) offer the opportunity to reduce the risks and cognitive burdens confronting military personnel. The Military European Land Robot Trial (M-ELROB) is organised every two years to evaluate the state of the art. Bundeswehr University, Munich (UniBw Munich) took part in M-ELROB 2016 with the robotic vehicles TULF and MuCAR-3 in the Convoy and Mule scenarios.

The M-ELROB scenarios are motivated from the perspective of military and civilian disaster control. They include unmanned reconnaissance in damaged buildings, the recovery of injured persons, and the driverless transportation of goods in a convoy or along trained routes (Mule). In comparing robotic platforms' capabilities, however, the organisers are less intent on electing a winner than on demonstrating the platforms' current possibilities and limits in real scenarios.

At M-ELROB 2016, held at the Tritolwerk CBRNE training facility in Austria, only the two mentioned transport scenarios were suitable for larger test vehicles.

The Institute for Autonomous Systems Technology of UniBw Munich was represented by its MuCAR-3 robotic vehicle in both scenarios. It additionally took part with the TULF vehicle in the convoy scenario as a member of the Smart Military Vehicles (SMV) team together with Diehl Defence and Hentschel System. Large parts of the algorithms in use were developed within the scope of BAAINBw (Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support) financed studies.

Fig. 1: Convoy scenario of M-ELROB 2016: aerial image of the competition area showing the path driven (blue), waypoints in a pregiven order (yellow) and mapped warning signs (orange)

Fig. 2: TULF ("Technologieträger unbemanntes Landfahrzeug", or Unmanned Land Vehicle Technology Demonstrator) stops in front of a dynamic obstacle during the convoy scenario. The sensors used for automated following are labeled

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In the first scenario a convoy had to complete a course over grasslands, field and gravel roads (Fig. 1). The driver of the guidance vehicle was given a map with waypoints that had to be passed in the correct order. The autonomous vehicles are equipped with various sensors (Figs. 2, 4), which are used in the algorithms for tracking the guidance vehicle. A model-based tracking algorithm matches previously learned 3D feature models to camera and LiDAR (light detection and ranging) data. Another algorithm works on 3D point clouds. Automotive radar and LiDAR sensors additionally provide several object hypotheses. To increase robustness, all information is processed by a downstream object-based data fusion algorithm (OBDF) (Fig. 3). Based on the OBDF results, a trajectory for automated lateral and longitudinal vehicle control is generated which is then followed using a drive-by-wire system.

The TULF (Fig. 2) uses the same software modules for vehicle tracking as well as the OBDF. Positional information from vehicle-to-vehicle communication is also used, this being of great advantage particularly if the leading vehicle leaves the field of view.

MuCAR-3 took first place in the convoy competition without any manual interventions, and the TULF achieved second place. The evaluation was based on the distance driven autonomously as well as on a subordinate reconnaissance task ("find orange signs marking hazardous materials, then map them and provide pictures").

The second scenario, Mule, is divided into two Teach-And-Repeat phases. In the first phase an autonomous vehicle learns and maps a path between two camps (teach-In, Fig. 4). In the second phase the vehicle repeatedly shuttles autonomously between the camps. For the teach-in phase, the LiDAR tracking version was optimised to detect and track persons (the guide). While the vehicle shuttles between the camps, the organisers repeatedly block individual parts of the route, making the implemented behaviour more complex since the vehicle has then to find alternative routes autonomously. The challenge in the Mule scenario thus lies mainly in the (re-)planning and navigation algorithms and in finding suitable paths and drivable terrain. The evaluation criteria were similar to those for the convoy scenario. MuCAR-3 shuttled more often than all the other teams and achieved first place, ahead of the SMV team in second.

To support the LiDAR technology in future, the use of stereo cameras in combination with hyperspectral cameras will be explored to a greater degree, possibly allowing identification of the material properties of recognised obstacles.

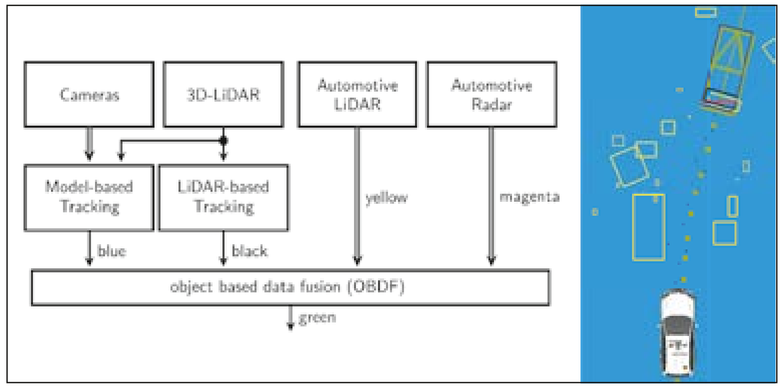

Fig. 3: Object-based data fusion in the convoy scenario: schematic overview of the data flow (left) and a typical scene with visualisation of the tracking results, including path driven by the guidance vehicle (right)

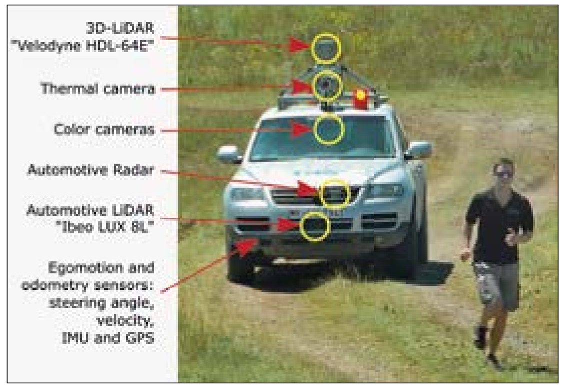

Fig. 4: Teach-in phase of the Mule scenario: MuCAR-3 automatically follows a person. The sensors used in the scenarios are labeled