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Will the driver Seat Ever be Empty?

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passive motion safety and it has been used in several autonomous vehicles. Passive motion safety is interesting for two reasons: (i) it allows provision of at least one form of motion safety guarantee in challenging scenarios (limited field-of-view for the robot, complete lack of knowledge about the future behaviour of the moving obstacles [3]), and (ii) if every moving obstacle in the environment enforces it then no collision will take place at all.

We are currently exploring more sophisticated levels of motion safety. We are also studying the relationship between the perceptual capabilities of

the self-driving vehicles and the levels of motion safety that can be achieved. The long-term goal of our research is to investigate if and how current self-driving technologies can be improved to the point that the human driver can safely be removed from the driving loop altogether, paving the way to truly self-driving vehicles whose motion safety can be formally characterised and guaranteed.

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Intelligent Environmental Perception for Navigation and Operation of Autonomous Mobile Machines

by Robert Rößler, Thomas Kadiofsky, Wolfgang Pointner, Martin Humenberger and Christian Zinner (AIT)

Research at AIT on autonomous land vehicles is focusing on transport systems and mobile machines which operate in unstructured and heavily cluttered environments such as off-road areas. In such environments, conventional technologies used in the field of advanced driver assistance systems (ADAS) and highly automated cars show severe limitations in their applicability. Therefore, more general approaches for environmental perception have to be found to provide adequate information for planning and decision making. As a special challenge, our focus is on vehicles that actively change their environment, e.g., by cutting high plants or manipulating piles of pellet materials. To operate such machines autonomously, novel approaches for autonomous motion planning are required.

In our latest research activity, a tractor (type Steyr 6230 CVT) was provided by the Austrian Armed Forces for the purpose of automating agricultural tasks on special areas. In a first step, this mobile machine was prepared in close cooperation with the manufacturer CNH Austria to serve as a mobile research platform. An electrical single-point interface provides access to the various functions of the tractor via actuators and the CAN bus system, which enables a set of additional computers and dedicated software to take over control. The vehicle is equipped with a multi-modal sensor system combining stereo vision, laser scanning, RTK-GPS and IMU to address difficult and varying outdoor conditions. A dedicated AIT stereo vision system mounted behind the windshield at the front and another on the rear of the vehicle provide dense 3D data of the tractor's environment (Figure 1).

An important step to further increase efficiency in farming is to develop completely driverless machines which

would, for example, enable one operator to monitor and control multiple machines at once. Thus, AIT investigates important computer vision based technologies and methods that improve the abilities of future autonomous vehicles and machines for agricultural applications. Furthermore, research is driven by a specific use-case defined by the Austrian Armed Forces: cultivation (e.g., mulching, mowing) of firebreaks on military training areas endangered by explosive ordnances. The technology developed by AIT allows the operator to safely monitor and control the semiautonomous machine from a safe distance with a high level of situational awareness.

The sensed 3D data of the stereo camera systems [1] and the laser scanner is continuously fused into an 'elevation map' – a 2.5D representation of the terrain. As the vehicle moves, the reconstruction of the vehicle's surroundings becomes more and more complete. An essential task is estimating the ego-

motion and the pose of the vehicle. The trajectories of the stereo visual odometries, the orientation of the inertial measurement unit and the position of the RTK-GPS are fused with an extended Kalman filter. The filter models the kinematics of the vehicle and computes a precise estimate of the pose [2]. Furthermore, the geometry of the elevation map is analysed in order to obtain a traversability map, which denotes drivable and non-drivable areas as well as obstacles around the vehicle. The map is organised using a tile based approach, which allows storing, loading and updating large scale maps. In that way the georeferenced mapped areas can also be accessed via a geographic information system.

The real-time traversability map is used by the path planning module to calculate a collision free trajectory along a predefined mission path. Dynamically appearing obstacles are avoided by calculating a local bypass route using a sampling-based motion planning algo-