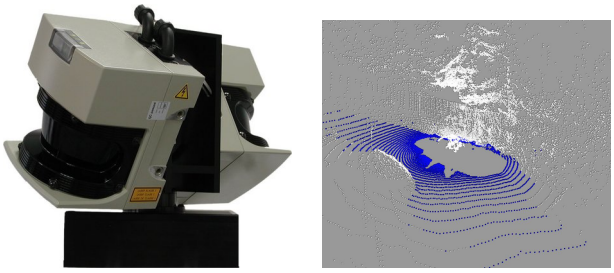
A 3D Laser Scanner System for Intersection Analysis and Autonomous Driving

Thomas Wisspeintner*, Francesco Maurelli†, David Droeschel*, Stefan May*, Hartmut Surmann* and Kai Pervoelz*
*Fraunhofer Institut IAIS, Germany †Sapienza - Università di Roma, Italy



(a) The Fraunhofer 3DLS-K (b) 3D Road Segmentation

Fig. 1. a) 3DLS-K, the 3D scanner developed by Fraunhofer IAIS b) road segmentation: road points are labelled in blue

TRAVELING BY CAR is currently one of the most dangerously forms of transportation, with over a million deaths annually worldwide. As nearly all car crashes are caused by human driver error, driverless cars would effectively eliminate many hazards associated with driving as well as driver fatalities and injuries. An autonomous intelligent vehicle helps to avoid dangerous situations and improves the traffic flow. It relieves in every day tasks, e.g. taxiing children to school or parking in narrow parking lots. Road segmentation, obstacle detection, situation awareness represent fundamental tasks which an autonomous vehicle must be able to perform in a efficient and robust way. The developed system, presented in this article, is based on the use of a novel 3D Laser Scanner, providing rich and robust sensor information about the environment for the task of motion planning.

A robust road segmentation algorithm has been implemented based on depth and remission values, as shown in Fig. 1. The processing of both values is prior in urban environments where the road boundaries often cannot be detected in depth measurements. Mastering intersections is a key issue for autonomous driving. Path planning can be done by employing GPS data, but traffic situations must integrate data acquired locally, e.g. mastering the passing of intersections. For this purpose an obstacle detection module has been implemented. Only with a sensor system capable to perceive the environment in the neighborhood of the car, a special crossing behavior can be implemented to determine, by a set of rules, if the car has the right to pass the crossing or not. The primary sensor for this task is the 3DLS-K, in Fig. 1, [1] which has been developed by Fraunhofer IAIS. It consists of two SICK LMS 291-S05 laser range finders mounted on an adjuster plate. This sensor is capable to acquire a circumferential 3D point cloud every 0.6 seconds. Analyzing the 3D points, the car is able to decide autonomously whether it has the right to enter the intersection and if it is a safe action. A common characteristic for 3D points to represent a car is to be at higher level than the road. Therefore, the steepness of a point is determined by the difference between its z-coordinate and its neighborhood. If the steepness exceeds a fixed threshold, the point is added to the list of steeppoints. As the car has information about the geometry of the intersection, steeppoints that are far away from a lane are discarded. The geometry of the intersection is built using way points and route node information, which constitutes the mapping between roads and lanes, as well as connections between them. According to the calculated geometry, regions of interest are calculated in the 3D cloud. Each region can be $free$ or $busy$, according to the number of steeppoint. A state machine models the decision process based on the crossing's structure and provided traffic rules. A signal is passed to the control module, whether the car can enter the intersection or has to wait for other cars to pass. The system was evaluated with success during the Darpa Urban Challenge [2], at South West Research Insitut, San Antonio, Texas, in Fig. 2 and in Victorville, California.

REFERENCES

[1] http://www.3d-scanner.net/.
[2] J. Rojo, R. Rojas, K. Gunnarsson, M. Simon, F. Wiesel, F. Ruff, L. Wolter, F. Zilly, N. Santrac, T. Ganjineh, A. Sarkohi, F. Ulbrich, D. Latotzky, B. Jankovic, G. Hohl, T. Wisspeintner, S. May, K. Pervolz, W. Nowak, F. Maurelli, and D. Droschel. Spirit of berlin: An autonomous car for the darpa urban challenge. Technical report, Freie Universitat Berlin, Fraunhofer Gesellschaft, Rice University, June 2007.

Fig. 2. $Spirit of Berlin$ facing an intersection