Research group: Institute for Autonomous Systems Technology
Head of group: Prof. Dr.-Ing. Hans-Joachim Wuensche

Contact Information

Postal address: University of the Bundeswehr Munich
Department of Aerospace Engineering
Institute for Autonomous Systems Technology
TAS
85577 Neubiberg
Germany

Street address: Werner-Heisenberg-Weg 39
85577 Neubiberg

Tel.: +49 89 6004 3588
Fax.: +49 89 6004 3074

Email: joe.wuensche@unibw.de
URL: http://www.unibw.de/lrt8

**Abstract:**

Our research group is headed by Prof. Dr.-Ing. H.-J. Wuensche, professor for “Autonomous Systems Technology” and successor of Prof. Dr.-Ing. Ernst D. Dickmanns at the University of the Bundeswehr Munich (UBM). Main focus of research at the Autonomous Systems Technology Institute is the development of cognitive autonomous mobile robot platforms. For example, such systems are to be enabled to autonomously explore and navigate in unknown unstructured environments. Main Sensors are vision and LIDAR based systems. As a demonstration platform, MuCAR-3, a modified VW Touareg, is available.

**Detailed research information:**

Our research group is headed by Prof. Dr.-Ing. H.-J. Wuensche, professor for "Autonomous Systems Technology" and successor of Prof. Dr.-Ing. Ernst D. Dickmanns at the University of the Bundeswehr Munich.

Main focus of research at the Autonomous Systems Technology Institute is the development of autonomous mobile robot platforms. For example, such systems are to be enabled to explore and navigate in unknown unstructured environments own their own. As a demonstration platform, MuCAR-3, a modified VW Touareg, is available, that is equipped with computer controlled actuation elements and sensors. "MuCAR-3" is the third generation of our Munich Cognitive, Autonomous Robot Cars, hence its name.

The first generation vehicle was "VaMoRs", which demonstrated fully autonomous driving on a not yet opened German Autobahn at its maximum speed of 96 km/h 20 years ago in 1987, covering a distance of 20 km. The second generation vehicle "VaMP" established further records in 1995, when it drove from Munich to Denmark and back for a distance of almost 1800 km, of which about 1660 km were driven fully autonomous at speeds up 180 km/h. The new vehicle was chosen to be a good vehicle both for participating in traffic on public roads as well as for off-road driving.

Apart from inertial sensors we continue to focus on vision as a main sensor for perception, as this sensor provides most of the information humans need for driving. In addition we use a high definition 360 deg. Velodyne laser scanner mounted on the roof of the vehicle. The main vision sensors are 3 forward looking cameras placed on a two-axis platform inside the vehicle.


The arrangement resembles the human vision system, with an inertially stabilized telecamera as "fovea" and 2 wide angle cameras for peripheral vision. All cameras are mounted on a yaw axis platform to allow for active control of the horizontal viewing direction.

Since 2009 we also work on a vision system for the humanoid robot "Lola" of the Institute of Applied Mechanics at TU Munich. The ultimate goal is to built a system that allows Lola to explore a realistic, non-simplified and apriori unknown environment, searching for an object, ideally an object the robot has to learn initially. The challenge of this goal is that both - navigation and object recognition - have to be integrated in a single working system.

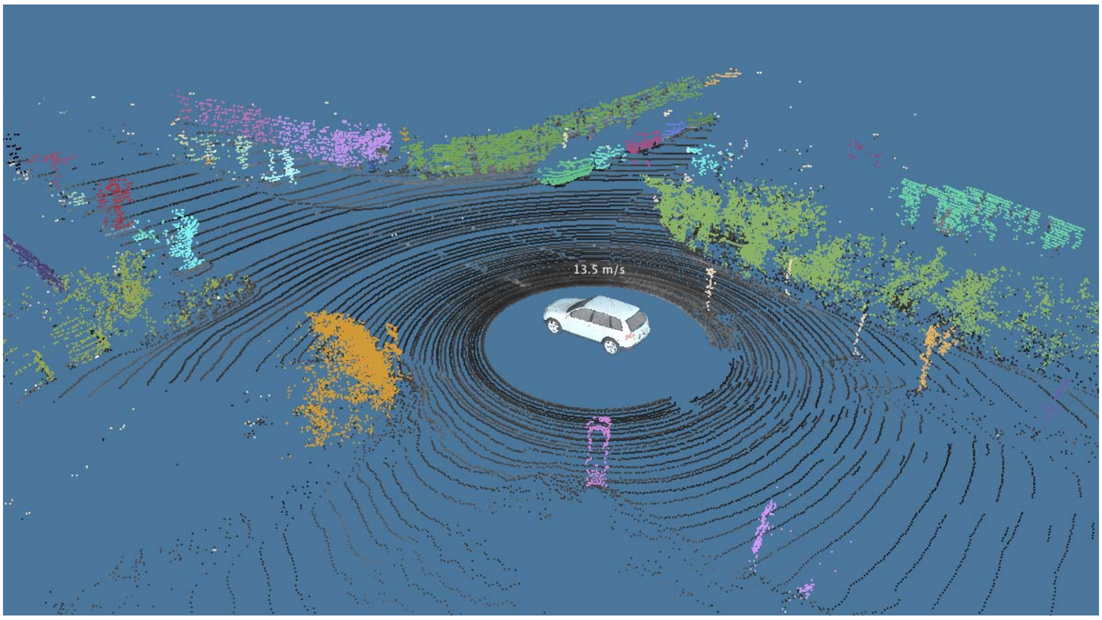
Gaze control is one requirement for our intention to develop biologically inspired systems for technical systems. It enables our robot to focus its attention to known objects of special interest (top down) and in addition to visually search the robots environment for new interesting areas to look at (bottom up). Our principle goal is the realization of cognitive perception on lower levels of the visual perception process, which we expect to enhance the performance of state-of-the-art computer vision approaches. In order to design such cognitive systems we have developed a new and extremely fast low level image point features extraction method called “SidCell”. Based on the significant computational power of modern graphics processing units (GPUs) our method allows to compute expectation based sparse optical flow to be used within our 4D-approach to update the internal 3D-world models of our robots.

Another branch needed by cognitive systems we are traditionally interested in is vision based autonomous road following where we further enhance our well known road tracking algorithm EMS-Vision to cope with unstructured environments like dirt roads or forest tracks under different weather conditions.

Therefore we develop enhanced tracking algorithms based on non-linear filter techniques as well as a robust extraction of visual road features within colour images.

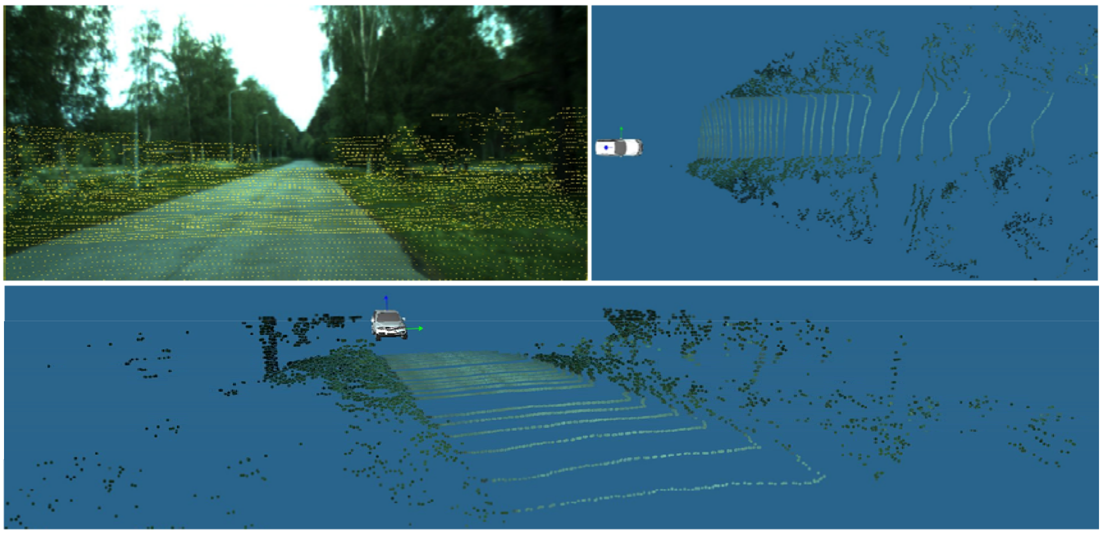
Providing immediate depth measurements at many points in the environment, our research on LIDAR based perception addresses the tasks hard to accomplish by visual perception alone. This includes modelling obstacles in the environment and providing obstacle avoidance methods for safe navigation, resulting in our “tentacles” approach to robot navigation that was successfully applied in different challenging environments and competitions (see below).

Apart from that, research is focused on the more complicated task of real-time object detection, classification and tracking in large 3D point cloud data, covering topics such as point cloud segmentation, extraction of features providing robust object descriptions from point clouds and machine learning.




Here, our ultimate goal is to let the robot learn meaningful object classes by itself without the need for human supervision.

Finally, combining the complementary benefits of both sensors, we are working on fusion of LIDAR and vision data to facilitate both environment modelling and object classification.



With the cameras only covering a small part of the 360 degree field of view of the laser scanner, research on this topic includes adaptation of methods developed in the field of active vision to LIDAR data in order to formulate reasonable camera gaze requests.

Up to know our research group participated in four challenging robotic contests:

Civilian ELROB 2007: Within the scenario "Autonomous reconnaissance" 90% of the very difficult mountain and forest track was driven fully autonomously in the fastest time of all competitors.

DARPA Urban Challenge 2007: Together with TU Karlsruhe and TU Munich we participated with great success as Team AnnieWAY which was one of only 11 teams which made it into the finals.

Military ELROB 2008: We participated in the scenario "Transport Convoy" where we were able to present robust and smooth autonomous convoy driving at speeds up to 70 km/h and convoy backward driving.

Civilian ELROB 2009: The scenario "Autonomous navigation" consisted of a track with a length of 5.2km through dense forest. Only MuCAR-3 finished the race, driving 95% of the complete distance fully autonomously in 70% of the allowed time.