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Abstract:
At the Institute of Real-Time Learning Systems, the research focuses on 3D computer vision and real-time learning. These basic technologies are applied to outdoor robotic scenarios, which provide the ultimate litmus test for robustness and usability. Different vehicles (AMOR, PSYCHE, DORIS) are now operated to cover flexibly a very wide range of possible applications. By a 3D environment model, several types of objects like roads, obstacles, or persons are recognised. A full featured local and global map allows navigating autonomously in complex terrain while handling the present objects appropriately.

Detailed research information:

Building real robots, which are able to cope with the calamities of rough, natural terrain needs complex sensor systems and an in depth understanding of appropriately modelling of the environment. These are exactly the tasks the Institute of Real-Time Learning Systems (EZLS) has tackled and to a high degree solved with its robots AMOR, PSYCHE and DORIS.

AMOR

The ground robot AMOR (Autonomous Mobile Outdoor Robot) is built upon a commercial ATV (All Terrain Vehicle) platform by Yamaha. The mechanical platform allows a wide area of operational scenarios as it is robust and has notable cross-country capabilities on the one hand and is able to drive at high speeds while having a big operating range on the other hand. The sensor equipment of AMOR comprises various internal and external sensors enabling the robot to solve different tasks autonomously. The system design is highly modular and thus permits the mastering of many scenarios. Software-sided AMOR is equipped with several modules, which enable the robot to perform all actions necessary to act autonomously in a rough and unstructured outdoor environment. Beside the software prerequisites for autonomous navigation like local and global path planning and obstacle detection and avoidance, AMOR's software architecture comprises capabilities like vehicle & person following and textured 3D-map generation to mention only a few.

By employing active (laserscanner) and passive sensors (video camera) in the following system either robustness is improved or the sensor type can be adapted to the task e.g. if active radiation is undesired.

Different internal models are available for an adequate environment description. While often point clouds are used (which are also available in our system) a surface model delivers a more powerful and easier to interpret representation. These scenes can be easily understood by untrained personal on a 3D screen. They are also much more robustly analysable by algorithms than other representations. Relevant objects like dirt roads, pathways, obstacles, and persons are recognised in the scene.

The above figure shows an image of 3D surface model extracted from REAL scan data. Such scans can be gathered in real-time with a low cost scanning system.

PSYCHE

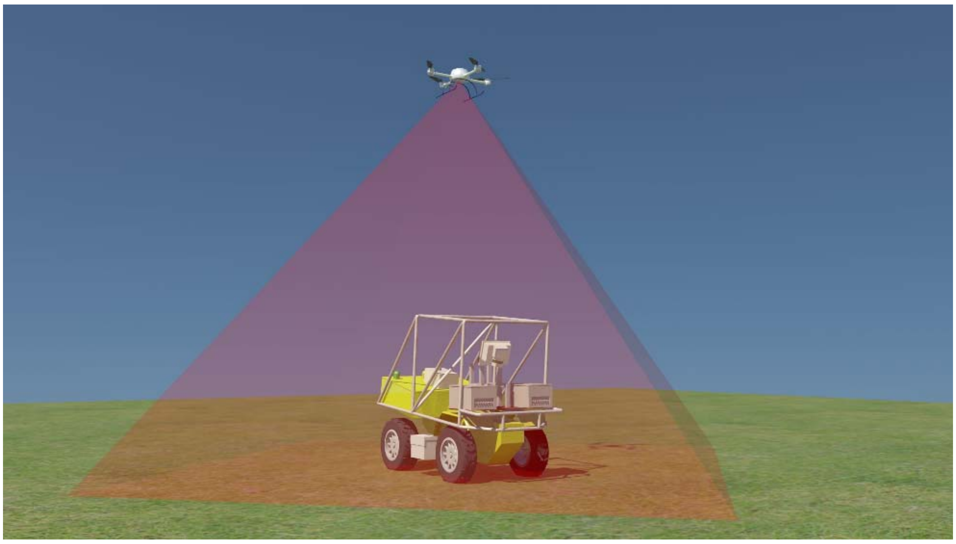
Here shortly our MUAV PSYCHE will be described because it is used to substantially support the ground operation of its sweetheart AMOR. It is based on a commercial Quadrocopter, the MD4-200 from Microdrones, but for real operation a MD4-1000 will be used which can also be deployed at strong wind.

The original system is primary intended for remote controlled operation and has only a minor level of autonomy. Now an additional microcontroller can control the MUAV and gets the telemetry data with all the necessary information to do flight operations. In our experiments, we are using sonar, radar and a custom made optical flow sensor, which measures the absolute movements of the MUAV over ground.

At the software side the VSAL architecture was ported from AMOR to the new target. The VSAL was originally developed for our UGVs and realized a highly flexible infrastructure to access sensors and actuators through a CAN bus or Ethernet. The VSAL client is created from an XML description file of the robot through code generation technology and offers a comfortable C++ programming interface to the user.

In the field of autonomous flying, we are working on: position hold without GPS, autonomous indoor and outdoor flying, autonomous precision landing and optical localization. The main topic in this context is to support the UGV by the UAV.

Ground support by UAV



This research focuses on combining ground and aerial vehicles to perform complex tasks, which the robots would not have been able to perform each on their own. An application of ground-air cooperation in robotics was published by our institute recently and deals with the absolute localization of a GPS-less ground vehicle. The aerial robot is used to acquire live video imagery, which the ground robot uses to realize a registration with geo-referenced orthophotos from a geo-database. This finally enables the ground robot to do a highly precise and absolute self-localization. The system has been successfully demonstrated with our robots AMOR and PSYCHE. Currently we are working on various other scenarios, which incorporate the combined use of ground and aerial robots.

DORIS

Our new amphibic robot DORIS (Dualmedia Outdoor Robotic Intelligent System) is a second-generation outdoor robot quite ripe for the applications. The electronics has been shrinked down to a 6HE 19' rack while safety and robustness are improved.

The robot is able to operate and on solid ground with up to 45km/h and in water up to 25km/h but also in very heavy mixed terrain. Due to the large payload of up to 400 kg in water, it can be used by several persons and also for load intensive autonomous tasks; an example would be the mule shuttle for heavy operation equipment.

These new areas of research focus on bridging the gap between mobile robotics on land and at sea. We build the world's first amphibious robot, which can traverse land, water, as well as quicksand-like mud with appropriate high speed. The complicated task of changing autonomously from ground to water driving is being solved at the moment.

An amphibic vehicle with 8 low pressure tires and jet impeller engine is used as the mechanical platform. Because it is able to carry substantial payloads on land and in water, it is well suited for researching the basic operation principles of autonomous amphibic systems as well as a bunch of applications like:

1. Autonomous in-water search and surveillance operations in littoral waters
2. Maintenance of plants in coastline areas
3. Applications such as detection of mines, biological, chemical or radioactive threats in water based and land-based environments
4. Exploring aquatic environments such as coral reefs or swamps