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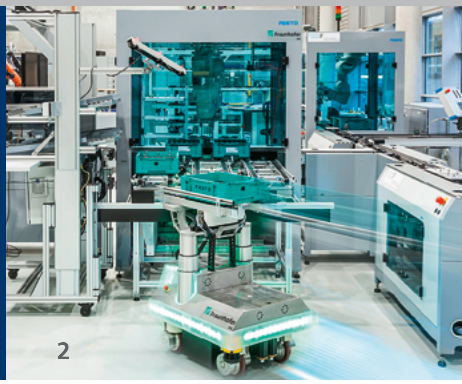

1 *AGV of Bär Automation with navigation software of Fraunhofer IPA. (Source: Bär Automation GmbH)*

2 *Precise navigation due to integration of a tracking system.*

FLEXIBLE NAVIGATION OF AUTONOMOUS SYSTEMS IN DYNAMIC ENVIRONMENTS

Background

Increasing flexibilization in automation is leading to the use of mobile robot systems in ever more areas of application. This trend goes hand in hand with high requirements in terms of the navigation of robot systems.

Also, the workspaces of humans and machines are moving ever closer together. This is especially true of autonomous mobile systems such as automated guided vehicles or mobile service robots, which are already today used in dynamic environments. On the one hand, proximity to humans calls for a high degree of safety and reliability while, on the other hand, the systems must be capable of flexibly reacting to changes in their environment.

Our solution

Fraunhofer IPA has many years of experience in developing software for the navigation of autonomous systems. These software modules are used in a variety of applications and environments, in both industrial and public settings. Their reliability and safety in direct proximity to humans has been demonstrated by, in some cases, several years of continuous operation.

Localization and mapping

Localization of an autonomous system is accomplished by the fusion of various sensors. The more sensors are used, the more accurate, stable and robust the localization system will be. However, this demands higher standards of the sensor fusion module, which must be capable of processing a multiplicity of different sensor signals. A modular approach allows Fraunhofer IPA's sensor fusion module to meet these requirements and to implement customized sensor configurations to suit particular applications.

Fraunhofer Institute for Manufacturing Engineering and Automation IPA

Nobelstrasse 12 | 70569 Stuttgart
Germany

Contact
Dipl.-Ing. Matthias Gruhler
Phone +49 711 970-1315
matthias.gruhler@ipa.fraunhofer.de

Dr.-Ing. Kai Pfeiffer
Phone +49 711 970-1226
kai.pfeiffer@ipa.fraunhofer.de

www.ipa.fraunhofer.de/robotsystems


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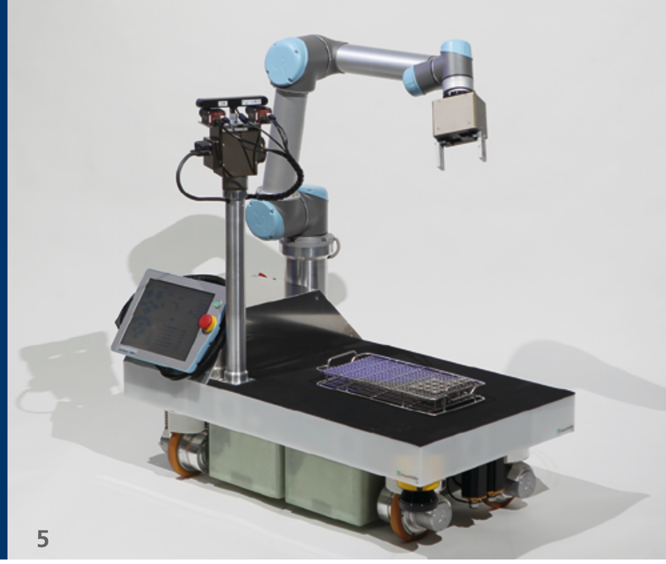
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The following sensors can already be integrated; the list can be extended to meet individual requirements:

– Odometry by motor encoder and IMU
– Laser scanner
– RFID
– (Indoor) GPS
– Mono, stereo and 3D cameras.

The environment map required for localization can be generated from existing environment data (CAD data, floorplans, etc.). Alternatively, it can be independently learned by the autonomous system before and during the runtime by means of SLAM (Simultaneous Localization and Mapping).

Path planning and path optimization
Path planning for a vehicle determines a suitable trajectory to the desired destination. This takes account of both the geometry of the vehicle and also its chassis kinematics, together with continuous optimization of the computed path. Depending on the environment in which the vehicle is used, a choice can be made between the planning methods "destination-oriented" (e.g. for transport tasks) and "area-covering" (e.g. for floor cleaning). With the environment map serving as a basis, planning can be either fully autonomous or by following predefined trajectories.

Path optimization uses not only the environment map, but also real-time 2D and 3D sensor data. This allows the trajectory to be adapted to changing situations, e.g. if points along the originally planned path are inaccessible because of dynamic obstacles.

Undercarriage control
Undercarriage control ensures that speed commands sent to the vehicle are translated into smooth and efficient motions. In the case of simple kinematics, such as differential drives, the incoming speed commands are converted directly into control signals for the drives. A more complex, e.g. pseudo-omnidirectional, undercarriage requires precise coordination of the individual drives. An additional controller cascade is integrated for this purpose. The additional use of potential-field-based controllers makes it possible to avoid singular configurations already at the lowest control level and thus to reduce the complexity in higher application layers.

Reference projects

Automated Guided Vehicles
In the area of automated guided vehicles (AGVs), Fraunhofer IPA collaborated with Bär Automation GmbH to add various sensor modalities to the previously trackguided navigation of AGVs. This increases the flexibility of the vehicles, because the trajectories can be generated in virtual form and thus be quickly and easily changed. Also, in association with MLR System GmbH, Fraunhofer IPA implemented a landmark-based localization system in a hospital setting as well as a tracking process for the lifting of pallets.

Driver assistance systems
By transferring technologies from service robotics, Fraunhofer IPA, in collaboration with partners from the automotive industry, successfully improved the performance of driver assistance systems while at the same time reducing costs. This involved the use of environment-sensing and modelling technologies that had originally been developed for the navigation of mobile robots.

What we offer

Fraunhofer IPA will assist you in all the development phases of your specific navigation software:

- Advice in connection with the design and selection of navigation processes
- Licensing/development/improvement of navigation modules
- Integration of new navigation modules into existing vehicle controls
- Customized development of your com-plete vehicle control

Contact us to discuss your own application scenario

3 Care-O-bot® 4 is able to navigate safely in dynamic environments.
4 CASERO (MLR System GmbH) in a hospital.
5 Mobile manipulator rob@work with navigation software by Fraunhofer IPA.
(Source: Fraunhofer IPA, Foto: Christian Hass Stuttgart)