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1 *AGV from Bär Automation with navigation software from Fraunhofer IPA. (Source: Bär Automation GmbH)*
2 *AGV at BMW with navigation software from Fraunhofer IPA. (Source: BMW/Günter Schmied)*

NAVIGATING AUTONOMOUS SYSTEMS FLEXIBLY IN DYNAMIC AND CHANGING ENVIRONMENTS

Introduction

Mobile robot systems are a key element in automation in order to realize the increasing level of flexibility required for changeable production and logistics systems. At the same time, however, the demands on the autonomy of robot systems are also rising, especially when it comes to navigation. Another challenge is the increasing convergence of man and machine working areas. The systems must be able to operate efficiently in these dynamic environments.

Our solution

Fraunhofer IPA has many years of experience in developing navigation software for autonomous systems. The software modules are implemented in diverse applications and environments in both industrial and public sectors. Their reliability, safety and efficiency in proximity to people have already been proven over several years of continuous operation.

Localization and mapping

The robust and precise localization of autonomous systems in dynamic, changing environments is the basis of autonomous navigation. The objective is often to achieve this without or with as little additional infrastructure (markers or additional sensors) as possible.

The developed software module "Longterm SLAM" (SLAM = Simultaneous Localization and Mapping) meets these demands by merging all available sensor information required for localization. In addition, it detects changes in the environment and updates the internal environment model accordingly. Without the need for manual mapping, it is thus able to generate a continuously updated map of the environment even in long-term operations. This also ensures accurate localization without restrictions, even if changes take place in the environment.

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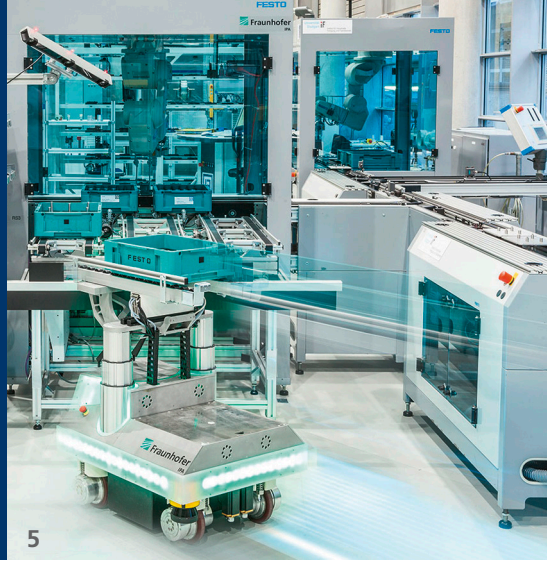

Path planning and optimization

The task of global path planning is to determine the optimum path to a given target while considering the geometry of the mobile robot and the kinematics of its drive system, as well as application-specific criteria (e.g. prohibited areas). During motion execution, the "Elastic-Band" software module then continuously optimizes the calculated path based on current 2-D and 3-D sensor information, thus enabling the robot to avoid unforeseen obstacles. In addition, by using the current map of the environment supplied by "Longterm SLAM", the route network can be continuously updated and adapted to the changing environment. Depending on the robot's operating environment, a "target-oriented" or "area-wide" planning method can be selected.

Cloud-based navigation

Classic navigation systems for mobile robots calculate localization and path planning / optimization based on the information from their own on-board sensors, which restricts their view and information horizon. This limitation can be overcome by networking the individual mobile systems, and additional navigation intelligence and efficiency realized for the entire fleet.

Fraunhofer IPA's "Cloud Navigation" takes advantage of this networking aspect. In addition, CPU-intensive navigation algorithms can be outsourced to the (private) cloud server's external computing resources. On the localization side, "Longterm SLAM" becomes a "Collaborative Longterm SLAM", in which all mobile systems and other sensors in the environment work together to update the map of the environment, detect each other and exchange localization information.

The advantage for the path planning task is that the fleet can be optimally coordinated, taking into account the collaboratively generated environment model. In addition, collaborative navigation makes more efficient use of time and energy, especially at bottlenecks and intersections.

Apart from this, the data collected by "Cloud Navigation" can be used to simulate material flows in real time. These are made intuitively accessible to the user via augmented reality glasses.

Reference projects

Automated guided vehicles

In collaboration with Bär Automation GmbH, Fraunhofer IPA has developed an automated guided vehicle (AGV) system for automotive production. The individual vehicles navigate freely with millimeter precision. Even after putting the system into service, it is easy to change existing paths or add new ones, thus making production adaptable.

Autonomous outdoor logistics

Autonomous systems can now also be navigated flexibly when it comes to outdoor logistics. Together with partners from industry, Fraunhofer IPA has developed AGVs that reposition containers on the factory premises. In collaboration with TeleRetail Aitonomi, an autonomous rover has also been developed that can run errands and do the shopping.

Scope of services

As an independent technology partner, Fraunhofer IPA assists you during all phases of development of your individual navigation software:

- Advice on the design and selection of navigation procedures
- Licensing or further / new development of navigation modules
- Integration of new navigation modules in existing vehicle controls
- Individual development of your complete vehicle control system
- Analysis of automation potential

3 *Care-O-bot 3 navigates customers at Saturn to the desired product. (Source: Saturn)*

4 *Autonomous rover from TeleRetail Aitonomi with navigation software from Fraunhofer IPA. (Source: TeleRetail Aitonomi)*

5 *Mobile robot rob@work with IPA navigation software. (Source: Fraunhofer IPA/Universität Stuttgart, Photo: Rainer Bez)*