PAN-Robots
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Plug&Navigate robots for smart factories

Specification and Architecture

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Coordinator		Kay Fuerstenberg, SICK AG
Author(s)		Markus Boehning, SICK Kay Fuerstenberg, SICK Christoph Reinke, SICK Matteo Foppoli, E80 Lorenzo Sabattini, UniMORE Valerio Digani, UniMORE Marius Drulea, UCLUJ Uula Kantojärvi, VTT Aki Mäyrä, VTT
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Executive summary

In modern factories, product processing and packaging have often reached a high degree of automation, in which energy consumption, agile manufacturing and product customization are well addressed. However, the degree of automation in factory logistics, that is the transportation of raw materials to storage areas or production lines as well as of final products from the production lines to storage areas or directly to shipment points, is only marginal.

Factory logistics thus constitutes a major bottleneck for mass production, creating a need for significant optimization. This fact substantiates the project vision of PAN-Robots: a highly automated logistics system supporting future factories to achieve maximum flexibility, cost and energy efficiency while at the same time ensuring accident-free operation.

Unfortunately, today's technology for factory logistics automation is still in an early stage of development and its deployment in the factory requires a trained staff and involves several time-consuming, costly, inflexible and sometimes even error-prone manual tasks. Therefore, the overall project objective of PAN-Robots is to develop, demonstrate and validate a generic automation system for factory logistics in modern factories based on the use of advanced automated guided vehicles (AGVs).

The PAN-Robots consortium proposes a new generation of flexible, cost effective, safe and green AGVs that will be able to transport material and products in modern factories autonomously, intelligently and efficiently. In order to achieve this project objective and to support the project vision, current technologies need to be significantly enhanced and a number of new approaches and technologies need to be developed.

The process of plant exploration and AGV deployment, currently involving many costly, time-consuming, error-prone manual tasks, needs to be greatly automated using high-precision sensor technology and advanced data processing algorithms.

The currently rather rigid AGV fleet and mission management performed in the control center needs to be replaced by a flexible assignment of resources, intelligent AGV navigation and increased system safety. This is achieved by managing a multi-layer map of static and dynamic objects in a so called global live view that is fed with the information acquired by the AGV fleet and the infrastructure-based environment perception systems. Additionally, human operators need to be able to easily assign custom missions to available AGVs.

Intelligent global and local AGV navigation is approached by two complementary functionalities: flexible global route assignment for each mission avoiding congestion zones or other reported obstacles by the control center on the one hand, local path planning on-board the AGV in case of unexpected obstacles in the current path.

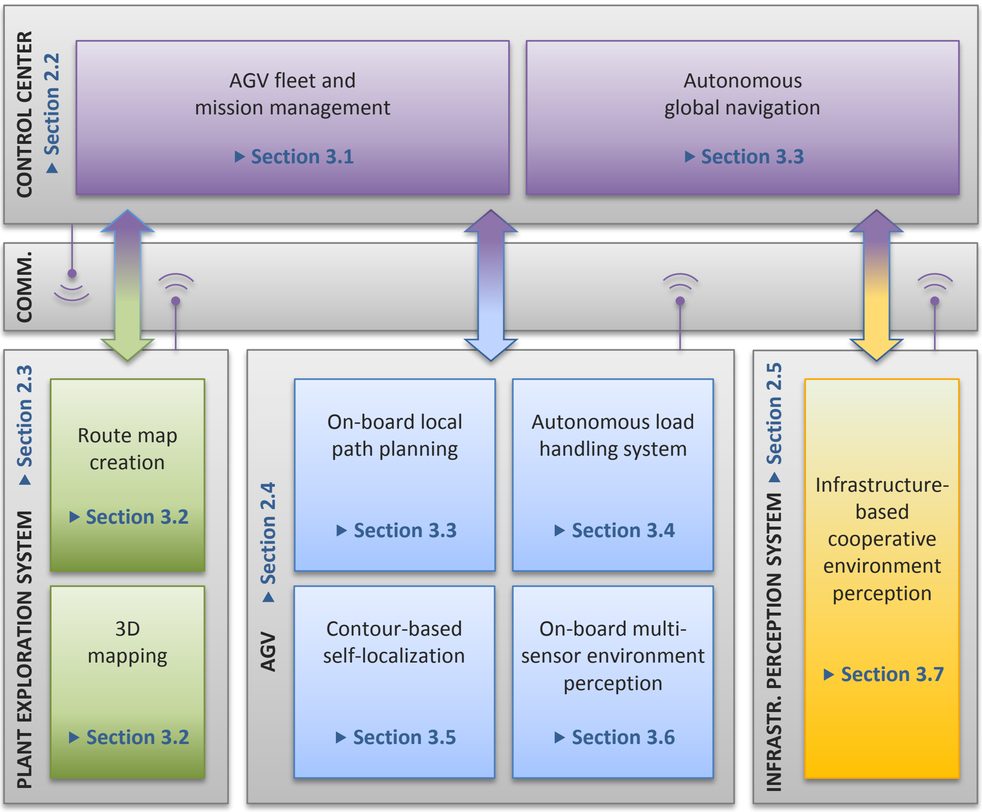
Load handling, the task of loading and unloading of goods, is currently a time-consuming, sometimes unreliable procedure. A comprehensive, general and reliable autonomous load handling system suitable for all different load handling tasks is required. This is addressed e.g. by a dedicated stereo camera for picking position identification and for visual servoing of the AGV to the required operation point in front of the pallet.

While reflector-based self-localization works reliably in the presence of sufficient artificial landmarks, the work load for reflector layout planning, mounting and mapping is very high and costly. A new approach relying on the identification of natural landmarks in the warehouse provides a much more effective contour-based self-localization. A seamless transition between these two modes provides reliable and accurate self-localization of the AGVs in all areas of the warehouse.

The existing 2D safety concept based on safety Laserscanners provides reliable collision avoidance. However, the system is challenged by highly dynamic objects, objects occluded by structural elements, protruding from the side or dangling from the ceiling. By advanced on-board 2D safety enhanced by 3D omnidirectional perception in combination with sophisticated risk assessment and collision avoidance strategies, these challenges can be mastered to provide accident-free and more efficient AGV operation.

An entirely new concept will be the installation of infrastructure-based environment perception systems for blind spot monitoring for cooperative safety. The information about tracked objects near the blind spot is communicated to AGVs in the vicinity via the control center in order to avoid collisions and increase efficiency.

This deliverable states the specification, architecture and interfaces of all systems and subsystems to be developed within PAN-Robots. In total, PAN-Robots will develop four main systems: the control center as the heart of AGV fleet and mission management, the plant exploration system for the 3D mapping of the warehouse, advanced production AGVs, as well as infrastructure-based environment perception systems, as shown in the following diagram.



The top-level architecture of these four core systems is discussed in ▸ Chapter 2.

Subsequently, in ▸ Chapter 3, the individual subsystems are characterized by detailed architectture diagrams. These diagrams offer three different views on the system: the layered, the soft- and the hardware architecture. A dedicated connection diagram showing the vnterconnecttion of the individual hardware components as well as detailed descriptions of both the hardware components and software modules complement each system description.

In conclusion, the specification and architecture for all systems to be developed in PAN-Robots have been documented in this deliverable. Different views on the system explain the layered architecture, the deployed hardware components and the functionality of the main software modules.