PAN-Robots
Collaborative project
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Publishable Summary

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Publishable 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, as illustrated in Figure 1 below.

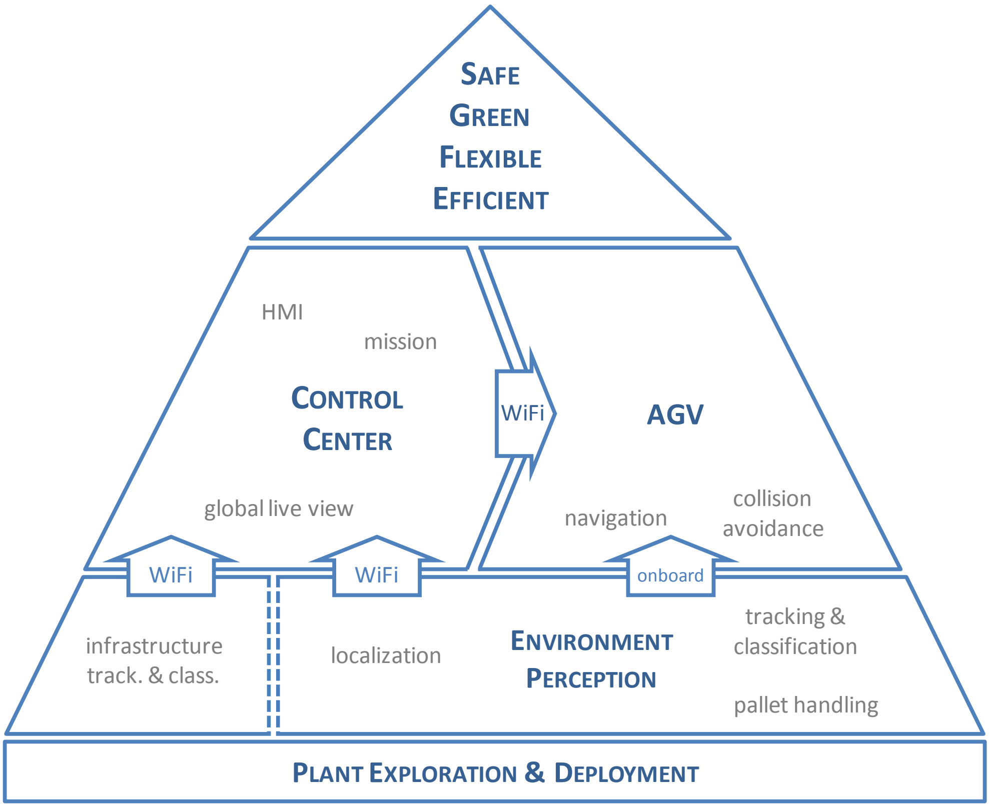

Figure 1: PAN-Robots key technologies

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 on-board sensors of 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 laser scanners 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.

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. The figure below shows these four systems, the hosted key technologies, the partner responsibilities as well as the system interconnections.

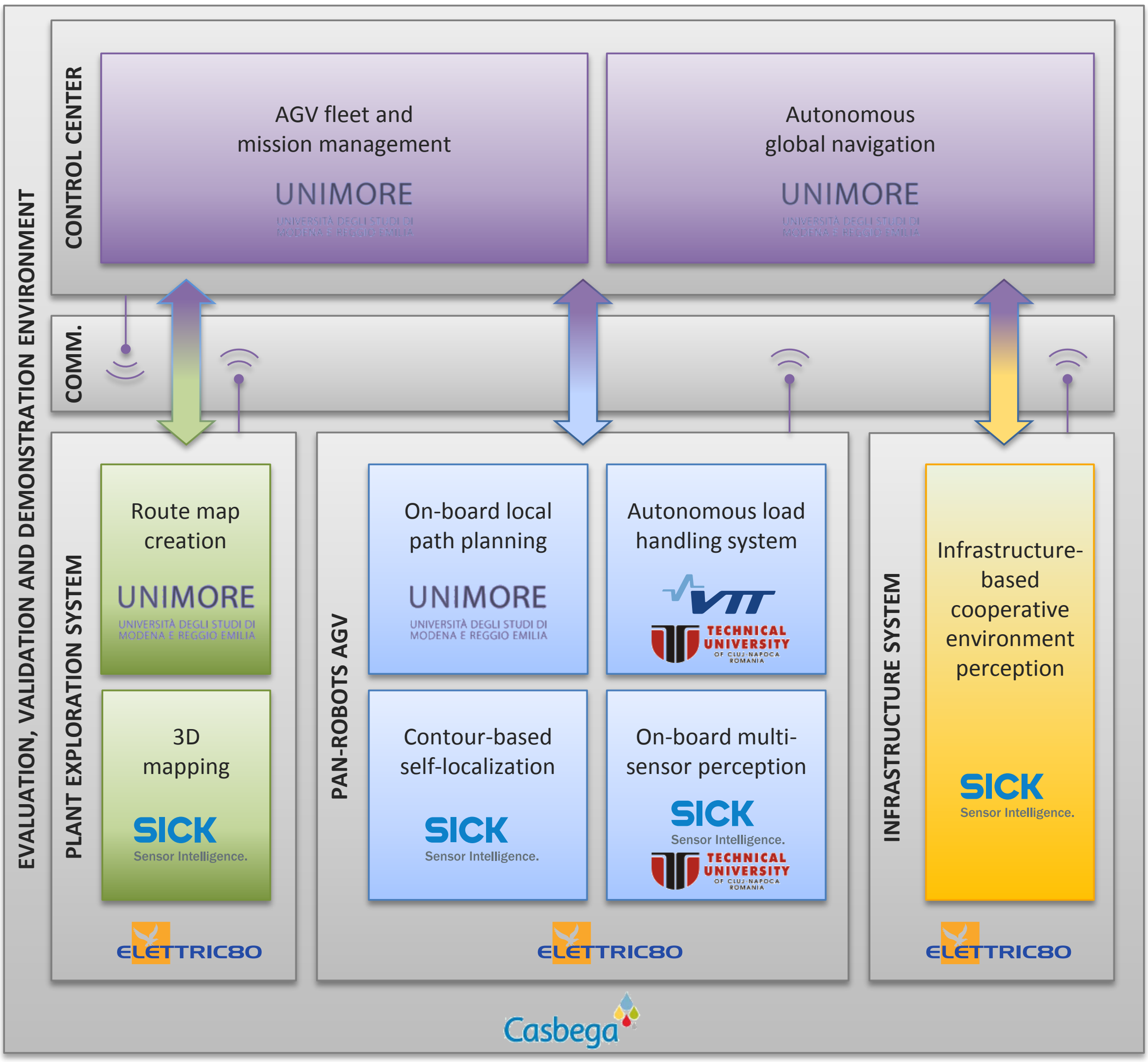

Figure 2: PAN-Robots main systems, information exchange and partner responsibilities

In the course of the second period of the PAN-Robots project, all planned steps towards these objectives have been performed successfully. This includes the non-technical activities such as dissemination and exploitation tasks.

The dissemination of the PAN-Robots project is a key factor for a successful project. PAN-Robots presented outstanding intermediate results at several reputed conferences such as the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) in Tokyo (Japan, 2013) and Chicago (USA, 2014), the International Conference on Robotics and Automation (ICRA) in Hong Kong (China). Furthermore, a public status report comprised of two dedicated PAN-Robots sessions with eight presentations was organized both at the European Robotics Forum (ERF) in Rovereto (Italy), and at the IEEE International Conference on Intelligent Computer Communication and Processing (ICCP) in Cluj-Napoca (Romania). There have been 18 presentations, one workshop stand and one poster session in the second project year. In sum, there have been more than 30 dissemination activities in the first two reporting periods.

The project website at www.pan-robots.eu was updated regularly, it was frequented by international experts and the access statistics have been monitored. In addition to these comprehensive dissemination activities, the implementation plan and as well as the intermediate report on contribution to standards deliverables have been compiled, reviewed and submitted.

On the technical side, the development of the PAN-Robots key technologies has successfully continued throughout the entire project year. In the second quarter of the reporting period, the key technologies reached maturity for intermediate testing, completing Milestone 3. The intermediate testing of the key technologies showed that all interfaces work reliably as specified and the expected performances are not only fulfilled, but even exceeded. All results were documented in the respective preliminary system tests deliverable.

Three extensive measurement campaigns, one in the Elettric80 demonstration warehouse in Viano (Italy) and two more in the Coca-Cola Iberian Partners warehouse in Bilbao (Spain) were performed to support the process of key technology development in order to evaluate and refine the respective components and modules. At the end of the reporting period, the key technologies have pushed the state of the art in various aspects and reached maturity for integration, completing Milestone 4. The development results were thoroughly documented in a dedicated deliverable for each key technology.

In parallel to the technical tasks, the project management has coordinated the project work and ensured the focus of all partners to their specific tasks in line with overall objectives. A particular focus was given to a detailed risk planning including backup solutions for critical components and modules in order to minimize the overall risk of achieving the project objectives. For a transparent and continuous project controlling, quarterly reports have been compiled, describing the work performed as well as the used resources and meetings held.

The project partner ‘Compañia Castellana de Bebidas Gaseosas S.A. (CAS)’ was merged with other Coca-Cola bottling companies on the Iberian Peninsula to form a new corporate group called ‘Coca-Cola Iberian Partners S.A.’ (CCIP). In the process of this corporate reorganisation, the bottling plant in Madrid, originally foreseen to host the project’s testing, evaluation and final demonstration, was closed. However, a bottling plant of CCIP in Bilbao was inspected and found suitable for the purposes of the project.

Although this shift posed additional efforts on the project work, the consortium handled the transition effectively and took the change as a challenge rather than a burden. The additional measurement campaigns in Bilbao helped improve the PAN-Robots systems further and even increased their robustness.

The overall project has continued successfully. The key technologies have excellent performance and are ready for integration. The PAN-Robots consortium is confident in outstanding outcomes of the project in terms of massive improvements in AGV deployment time, operation safety and efficiency, to be exemplified in a demonstration event in a CCIP warehouse at the end of the project in October 2015. The developed systems will pave the way for a new generation of smart AGVs for factories of the future.