PAN-Robots
Collaborative project
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Plant Exploration

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Executive summary

Today modern manufacturing and logistic processes rely in most instances on manual forklifts. The PAN Robots research project aims to replace them in large scale with automated guided vehicles (AGV).

Currently, the initial installation time and costs of the AGV system is very high, since every possible pallet position in every rack, the free space, the conveyors, safety markings, and the reflector landmark positions need to be determined manually and the warehouse route map for AGV navigation needs to be designed by trained experts.

European penetration of robotized AGV in truck forklift market is approximately 1 %. The major bottleneck is the initial plant exploration. Warehouses in operation cannot afford to stop production for 6-12 months to integrate AGV technology. Thus, just the minority of newly built warehouses are in the focus for AGV systems.

The aim of PAN-Robots is to reduce the required installation time dramatically from months to weeks in order to open up all warehouses as potential market. Thus, the PAN-Robots **technical objective 3** [1] is the development of a laser scanner based 3D mapping system to enable semi-automated plant exploration of new or modified warehouse areas in combination with a route map creation system to generate a warehouse route map for AGV navigation automatically.

3D mapping

First, this deliverable discusses a methodology to generate 3D maps with semantic information automatically from the data acquired through a special arrangement of SICK 2D laser scanners. A divide-and-conquer approach is taken in this work to solve the complicated problem of identifying warehouse elements by developing a variety of algorithms suited for various objects present in a modern warehouse.

We demonstrate how we successfully handle datasets of approx. 800 million points (approx. 37 GiB) representing a modern warehouse, and provides a semantic representation of the warehouse by means of the segmented semantic objects like floor, ceiling, pillars, poles, etc. This work provides a solution that improves the detection rate and the run-time of the algorithms due to the development of novel techniques.

There are multiple key improvements to the state-of-the-art:

- Development of a highly automated approach to initial warehouse deployment
- High confidence of feasibility of the approach due to measurements in two real world warehouses
- Highly accurate 2D mapping working solely on natural landmarks
- Novel segmentation and feature extraction approaches to thin object detection
- Two alternative 3D mapping units

We present our real world validated, current mapping and localization results based on measurement data acquired at the warehouses of our project partner Coca-Cola Iberian Partners (CCIP) in Madrid and Bilbao, Spain.

The outstanding results show how well the algorithms are suited for the task by deriving accuracy measures and comparing them against previously specified values. Here, we achieved the speci-

fied global accuracy of 5 cm. And even a local accuracy of 1 cm is achieved which enables a flexible and effective pallet loading and unloading approach.

Route map creation

Second, this deliverable thoroughly documents the algorithm development for operation point definition and warehouse route map creation. The objective of the automatic route map creation algorithm developed within PAN-Robots is that of providing an automated procedure for defining both the operation points and the route map. The input for this module is the 3D layout of the plant that precisely describes the position of all the infrastructural elements, determined based on the 3D point cloud of the warehouse.

The route map is developed in order to optimize the overall performance of the system, taking into account the strategy that will be used for coordination. Based on the size of the PAN-Robots AGVs used in the plant, and based on the accuracy of the localization system, a set of roads are defined, such that the AGVs are always able to reach their desired destination, while being sufficiently far away from the infrastructure elements, and among each other. Specifically, if two AGVs are on different segments, they never collide because the spacing between the segments is sufficiently big. Intersections among the segments are properly designed in such a way that they can be managed by the global navigation system. Details on the global navigation will be given in deliverable D6.1.