PAN-Robots
Collaborative project
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Perception Systems

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Executive summary

Modern automated guided vehicles (AGVs) are equipped with multiple safety laser scanners for an extremely reliable 2D omnidirectional environment perception to ensure avoidance of accidents with workers present in the warehouse environments. Such safety laser scanners scan a plane parallel to the ground and detect objects within defined safety fields and slow down or halt the AGV if required.

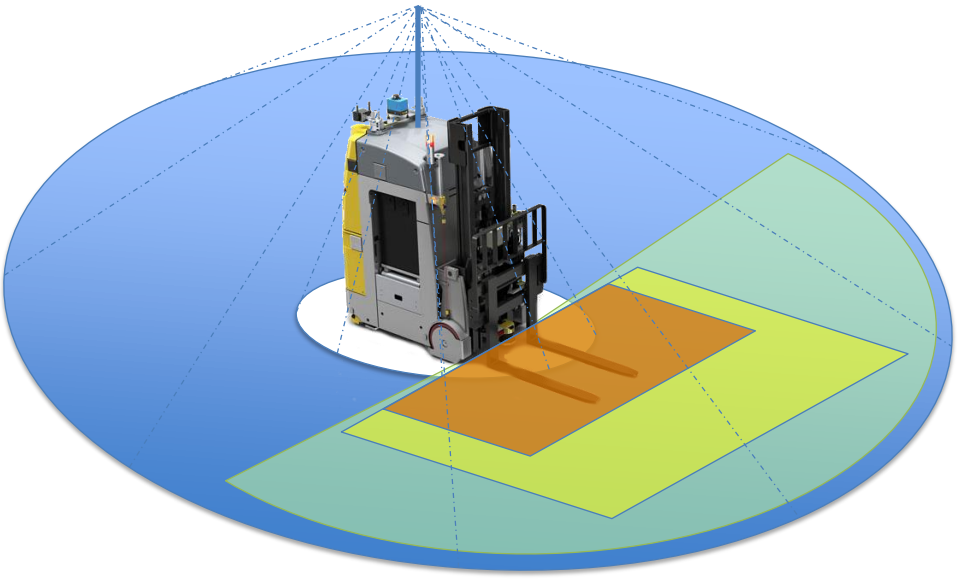
However, the use of the system beyond worker safety is quite limited. For example, objects protruding from the side or hanging from the ceiling into the pathway of the AGV are not detected by this sensor system due to its two dimensional nature and thus accidents with objects not directly connected to the ground cannot be avoided with the current sensor system.

The PAN-Robots **technical objective 7** [1] concerns the development of a novel on-board sensing system for AGVs by means of an omnidirectional stereo camera system and enhanced laser scanner algorithms.

The novel concept of 2D safety and 3D perception is realised by two natures of input data:

- 2D safety for human workers based on the use of multiple very reliable SICK safety laser scanners and
- 3D perception to avoid any kind of material damages based on the data provided by an omnidirectional stereo camera system.

In parallel to the evaluation of violation of the safety fields, the scan data of the safety laser scanners are used, as well. The following figure illustrates the two complementary perception systems.



A low-level fusion of the four safety laser scanners provides a very consistent and precise 2D observation all around the AGV. In addition the background elimination removes all measurements of static objects registered initially in the 3D semantic map, which enables a very efficient and reliable object tracking and classification. The objects are correctly tracked and classified and the required accuracies are achieved on the test data sets.

The algorithms developed for the omnidirectional stereo camera are based on the novel configuration and the usage of omnidirectional fisheye lenses (D5.1 [4]). Objects are visible up to a distance of 10 meters in each driving direction which makes such a system usable in these kinds of applications.

A real-time implementation on a graphics processing unit (GPU) of state-of-the art dense stereo reconstruction approaches is achieved in the project. The stereo algorithms are run on 3 separate pairs of images and the reconstructed points from the different channels are merged into the same coordinate system.

Based on the obtained reconstructed points a novel stereo reconstruction uncertainty based digital elevation maps (DEMs) is created. Instead of using empiric or canonical values for the probability distribution parameters, the actual errors are measured and interpolated in the field of interest. In addition, a novel way of classifying objects in image space is proposed in the context of factory logistics applications as well.

The novel on-board sensor system for comprehensive 2D safety and 3D perception developed in PAN-Robots is able to reliably detect, track and classify objects in the AGV's environment and thus pushes the AGV technology towards the vision of zero accidents in warehouses involving AGVs.