PAN-Robots
Collaborative project
FP7-2012-NMP-ICT-FoF

Localization

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Executive summary

Reflector-based self-localization for automated guided vehicles (AGVs) works reliably in the presence of sufficient artificial landmarks, but relies on cost-intensive professional layout planning, mounting and mapping of the reflectors.

The installation process of reflector layout planning, reflector mounting, reflector mapping and finally testing of the AGV localization is done iteratively and quite often, steps needs to be adapted and repeated. This process needs to be done by experts and is therefore very expensive and inflexible.

The PAN-Robots **technical objective 6** [1] is a seamless transition between reflector- and contour-based localization and localization in unknown areas to guarantee best localization performance for safe and efficient AGV operation. This robust localization solution is the basis for the PAN-Robots **technical objective 4** [1] of flexible and autonomous global on-board path planning and local navigation.

We met this objective with our new contour-based localization approach relying on raw laser scanner data utilising the existing warehouse environment like walls and racks. There are no modifications needed to provide a reliable and accurate self-localization of the AGVs in all areas of the warehouse.

The employed approach Adaptive Monte Carlo Localization (AMCL) utilises a pre-generated grid map representing the environment [5]. It uses a motion model to predict the movement of a vehicle and a measurement model to incorporate information obtained by laser scanners. As measurement model, we use the likelihood field model. The grid map is used to calculate the probabilities in the likelihood field. A subset of scan points projected from every particle is then evaluated using this field. Then every particle is moved according to the results of a laser scan matcher which are input for the motion model. This process is repeated over several scans and the weight of every particle is adapted accordingly.

In our studies in real large-scale warehouses this localization technique was able to achieve accuracies in terms of position error of less than 3 cm standard deviation (1 σ) and less than 15 cm maximum, while the standard deviation (1 σ) of the orientation error was less than 0.1 deg and the maximum error was less than 0.5 deg. The averaged results are reported in the table below.

In addition to the work originally planned for PAN-Robots, we also enhanced two other laser scanners with significantly lower list prices for localization and evaluated their performance with very promising results.

Table 1: Mean accuracy results obtained in two large-scale warehouses

<table>
<tr><th rowspan="3"></th><th colspan="4">Distance error</th><th colspan="4">Orientation error</th></tr>
<tr><th colspan="2">Std. deviation (1 σ)</th><th colspan="2">Maximum</th><th colspan="2">Std. deviation (1 σ)</th><th colspan="2">Maximum</th></tr>
<tr><th>Result</th><th>Spec</th><th>Result</th><th>Spec (3 σ)</th><th>Result</th><th>Spec</th><th>Result</th><th>Spec (3 σ)</th></tr>
<tr><td>Madrid</td><td>1.46 cm</td><td rowspan="2">< 5 cm</td><td>10.31 cm</td><td rowspan="2">< 15 cm</td><td>0.03 deg</td><td rowspan="2">< 1 deg</td><td>0.31 deg</td><td rowspan="2">< 3 deg</td></tr>
<tr><td>Bilbao</td><td>2.10 cm</td><td>12.48 cm</td><td>0.06 deg</td><td>0.41 deg</td></tr>
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