Simultaneous Calibration of Odometry and Sensor parameters for Industrial AGV

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Automated Guided Vehicles (AGVs) are commonly used to transport goods and to efficiently handle logistics of industrial warehouses. Accurate localization and navigation of AGVs depend on the correct assessment of their odometric or intrinsic parameters and of the position and orientation (or extrinsic parameters) of the exteroceptive sensors used for localization. Incorrect calibration causes systematic error and displacement of the AGV when reaching operation points.
This work presents calibration problem in a mathematical perspective and illustrates a method for the estimation of both intrinsic and extrinsic parameters. The proposed approach follows the principle presented in [1] for differential drive kinematic model and that have been applied to three and four wheel models [2, 3] commonly adopted for industrial AGVs. This approach compares the trajectory measured by the on-board sensor and the expected trajectory. To observe trajectories, the robot must be equipped with on-board sensors enabling egomotion estimation like laser scanners. These different measurements are encoded by a set of constraints among intrinsic and extrinsic parameters, which are exploited to perform least-square estimation.
The kinematic models addressed in this work include Tricycle, Ackermann and Dual Drive. Tricycle AGVs have three wheels with the front one actuated, whereas Ackermann and Dual Drive have both four wheels, but different configuration of actuacted and steering wheels. Due to modelling differences, the procedures for their intrinsic calibration are slightly differents, which mostly result in linear relations except for the asymmetric model of Tricyle. The four wheels models present observability issues, which require preliminar manual alignment of the front wheels of the robot. Closed-form solutions have been derived for all the formulations. The intrinsic calibration equations accurately describe the real motion of AGVs under the assumption of wheel alignment and negligible wheel slipping. The presented extrinsic calibration algorithm estimates the pose of the sensor once the kinematic parameters have been obtained. The proposed closed-form solutions are suitable for implementation on PLCs (Programmable Logic Controllers) used for industrial AGVs. The methods have been tested in real plants and enable full estimation of calibration parameters in about $10 - 15$ minutes. Repeated calibration trials have exhibited numerical stability and precision in the values of computed parameters. Positioning tests on actual AGVs have also demonstrated the higher accuracy of the proposed calibration algorithm w.r.t. manual calibration.

References

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