

Title: Odometry and extrinsic laser calibration with the robot's sensory system

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Abstract:

Nowadays, autonomous robots are more and more used in industry, services, and other applications. One of the most critical requirements for the robot is having the capability of locating himself within the environment in which it is inserted. Two basic methods commonly applied together using sensor fusion are absolute and relative localisation. Laser scan matching (2D or 3D) is an example of absolute localisation used not only for localisation but also mapping of environments (e.g., the use of laser scan matching for the Simultaneous Localisation and Mapping – SLAM – problem with mobile robots). Relative localisation can be performed with wheeled odometry by measuring the wheel revolutions (usually obtained from optical encoders) and/or steering angles.

However, the localisation methods that depend on external sensors such as laser scanners or Inertial Measurement Units (IMU) require a known rigid transformation between the sensors and the robot's coordinate frames. These rigid transformations allow the transformation of the data measurements from the sensors to the robot's frame used to locate the robot within a certain environment. In the case of estimating the extrinsic parameters of a laser – robot setup, the works proposed in the literature use scene features for 2D laser scanners (retro-reflective tape [1] or vertical poles [2]), constrains between the rigid transformations of 3D lasers, the robot's frame and the environment [3], and simultaneous odometry and 2D laser calibration [4]–[6]. As for odometry calibration (estimating the kinematic parameters of a robot such as diameter of wheels, distance between wheels or steering angle offsets), several works are proposed in the literature, but only the works [4]–[6] focused also on the extrinsic sensor calibration problem.

Therefore, we propose studying the problem of simultaneously calibrating the odometry and the extrinsic parameters of a mobile robot with 2D laser scanners. Although the works [4]–[6] already focus on this problem, their approaches estimate first the odometry parameters and then the extrinsic parameters (i.e., formulation of two independent problems) using the linear least-squares algorithm. Our approach will focus on studying the convergence of odometry and the extrinsic parameters by formulating an optimisation-based algorithm that uses the relative motion estimated from the two localisation methods (wheeled odometry and laser scan matching). We will use the same assumption of the works [4]–[6] (laser horizontally mounted on the robot – zero pitch and roll) because it decreases the number of extrinsic parameters from 6 (3 for translation and 3 for rotation) to 3 (2 for translation and 1 for rotation) parameters. The results of this study will compare the proposed method with the existent literature.

Work Plan:

The work plan is divided into 6 tasks described in Table 1. The estimated total workload of the project is 165 hours (~162 hours = 6 ECTS). The work will be supervised by Professor António Paulo and the senior researcher Héber Sobreira on a weekly basis. The mobile robot that will be used to implement the calibration methods is provided by the Centre for Robotics in Industry and Intelligent Systems (CRIIS) from INESC TEC – Institute for Systems and Computer Engineering, Technology and Science.

Table 1: Work Plan

#	Description	Hours
1	Theoretical formulation of the simultaneous odometry and extrinsic calibration problem	15
2	Implementation of the proposed method on a real mobile robot	35
3	Implementation of the method proposed by Kallasi et al. [5] for tricycle robots	25
4	Retrieve experimental results using the calibration methods implemented	20
5	Elaboration of the final report	35
6	Elaboration of a scientific article	35

References

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