Robust Self-Localization of Mobile Robots in Dynamic Environments Using Scan Matching Algorithms

By

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Abstract

The most fundamental task for any mobile robot is to perform self-localization in the world in which it is currently active, i.e. determine its position relative its world. Encoders that count wheel rotations are often used, which can be turned into relative position estimates by means of integration. This process is commonly referred to as dead reckoning. Unfortunately, the errors in such position estimates grow over time due to the underlying measurements errors, which means that the errors in the dead reckoning estimates must be regularly corrected by absolute position estimates provided by other sensors. The goal of this thesis is to evaluate the possibilities of using so called scan matching algorithms for robust position estimation of a mobile robot, especially in environments that change over time. A scan is a set of range measurements of the environment provided by e.g. a laser scanner. By comparing a scan taken at the actual position of the robot with a scan previously taken and stored in a map of the environment, an estimate of the absolute position of the robot can be obtained. It is important that scan matching algorithms are robust against changes in the environments, are robust against different types of environments and can judge their own results.

The main contributions of the thesis are threefold. First, two new sector-based scan matching algorithms are presented that are based on two existing scan-matching algorithms known as the Cox´s and IDC algorithm. The sector-based variants, Cox-S and IDC-S, increase the performance of the existing algorithms, especially in environments containing severe changes. Second, two new methods are presented for estimating the uncertainty of the IDC algorithm. These methods improve the self-judgment of the IDC and IDC-S significantly, as the existing method for estimating the uncertainty was not reliable. Third, the new sector-based scan matching algorithms are evaluated and compared to the existing algorithms on the basis of simulations and real world experiments made with two different mobile robots. The experiments focus on the performance of the algorithms in changing environments and on their performance as part of a complete localization system, i.e. fusing the outcome with dead reckoning. The experiments show a clear advantage of using sector-based scan matching algorithms in terms of increased robustness against changed environments. The experiments show that use especially of a combination of the two sector-based algorithms Cox-S and IDC-S, while also using the new method for estimating the uncertainty of the IDC-S, achieves significantly better performance in changing environments compared to the existing algorithms.