Available online at www.sciencedirect.com
ScienceDirect
Mathematics and Computers in Simulation 81 (2010) 590–607
MATHEMATICS AND COMPUTERS IN SIMULATION
www.elsevier.com/locate/matcom

Extended Kalman and Particle Filtering for sensor fusion in motion control of mobile robots

Gerasimos G. Rigatos

Unit of Industrial Automation, Industrial Systems Institute, 26504 Rion Patras, Greece

Received 12 February 2009; received in revised form 6 March 2010; accepted 5 May 2010
Available online 15 May 2010

Abstract

Motion control of mobile robots and efficient trajectory tracking is usually based on prior estimation of the robots' state vector. To this end Gaussian and nonparametric filters (state estimators from position measurements) have been developed. In this paper the Extended Kalman Filter which assumes Gaussian measurement noise is compared to the Particle Filter which does not make any assumption on the measurement noise distribution. As a case study the estimation of the state vector of a mobile robot is used, when measurements are available from both odometric and sonar sensors. It is shown that in this kind of sensor fusion problem the Particle Filter has better performance than the Extended Kalman Filter, at the cost of more demanding computations.

Keywords: Extended Kalman Filtering; Particle Filtering; State estimation; Sensor fusion; Motion control

1. Introduction

Feedback control algorithms for industrial and mobile robots require knowledge of the robot's state vector. The estimation of a robot's state's vector from position measurement is carried out with the use of filtering algorithms. It is well known that the optimal filter for linear model with Gaussian noise is the Kalman Filter [17]. State estimation for nonlinear systems with non-Gaussian noise is a difficult problem and in general the optimal solution cannot be expressed in closed-form. Suboptimal solutions use some form of approximation such as model linearization in the Extended Kalman Filter (EKF) [26]. More recently, Monte Carlo sampling from state vectors distribution has been used in the development of the Particle Filter. A particular advantage of this sample-based approximation is its suitability in applying it to the nonlinear non-Gaussian case [9,11].

The Extended Kalman Filter (EKF) is an incremental estimation algorithm that performs optimization in the least mean squares sense and which has been successfully applied to neural networks training and to data fusion problems [26,35]. In this paper the EKF has been employed for the localization of an autonomous vehicle by fusing data coming from different sensors. In the EKF approach the state vector is approximated by a Gaussian random variable, which is then propagated analytically through the first order linearization of the nonlinear system. The series approximation in the EKF algorithm can, however, lead to poor representations of the nonlinear functions and of the associated probability distributions. As a result, sometimes the filter will be divergent.

E-mail addresses: grigat@isi.gr, ger9711@ath.forthnet.gr.

0378-4754/$36.00
doi:10.1016/j.matcom.2010.05.003