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DEALING WITH PARTICLE FILTER SAMPLE IMPOVERISHMENT FOR ORBIT DETERMINATION APPLICATION

Abstract

The purpose is to discuss techniques for administering one implementation issue that often arises in the application of particle filters: sample impoverishment. Dealing with such problem can significantly improve the performance of particle filters, and can make the difference between success and failure. Sample impoverishment occurs because of the reduction in the number of truly distinct sample values. Eventually, all of the particles will collapse to the same va1ue, and the problem is exacerbated when modeling errors occur. This can be overcome by simply increasing the number of particles, which can quickly lead to unreasonable computational demands and often only delays the inevitable sample impoverishment. Other more intelligent ways of dealing with this problem, such as roughening, prior editing, regularized particle filtering, and auxiliary particle filtering, will be discussed in this work. The nonlinear particle filter used is based on the bootstrap filter for implementing recursive Bayesian filters. It is a statistical, brute-force approach to estimation that often works well for systems that are highly nonlinear. Here, the bootstrap particle filter will be implemented with resampling and schemes for combating sample impoverishment will be tested in terms of effectiveness. In this work, the application consists of determining the orbit of an artificial satellite using real data from the GPS receivers. This is a nonlinear problem, with respect to the dynamics and the measurements equations, in which the disturbing forces are not easily modeled. The problem of orbit determination consists essentially of estimating values that completely specify the body trajectory in the space, processing a set of observations that can be collected through a tracking network grounded on Earth or through sensors, like space GPS receivers onboard the satellite. The GPS is a wide spread system that allows computation of orbits for artificial Earth satellites by providing many redundant measurements. Throughout an onboard GPS receiver it is possible to obtain nonlinear measurements (pseudoranges) that can be processed to estimate the orbital state. The standard differential equations describing the orbital motion and the GPS measurements equations are adapted for the nonlinear particle filter, so that the bootstrap algorithm is also used for estimating the orbital state. The discussion to be presented will be evaluated through convergence speed and computational implementation complexity, comparing the bootstrap algorithm results obtained for each technique that deals with sample impoverishment. Based on the analysis of such criteria, the advantages and drawbacks of the implementations will be presented.