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RESAMPLING STRATEGY IN SEQUENTIAL MONTE CARLO FOR CONSTRAINED SAMPLING PROBLEMS

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Abstract: Monte Carlo sample paths of a dynamic system are useful for studying the underlying system and making statistical inferences related to the system. In many applications, the dynamic system being studied requires various types of constraints or observable features. In this study, we use a sequential Monte Carlo framework to investigate efficient methods for generating sample paths (with importance weights) from dynamic systems with rare and strong constraints. Specifically, we present a general formulation of the constrained sampling problem. Under such a formulation, we propose a flexible resampling strategy based on a potentially time-varying lookahead timescale, and identify the corresponding optimal resampling priority scores based on an ensemble of forward or backward pilots. Several examples illustrate the performance of the proposed methods.

Key words and phrases: Constrained sampling, pilot, priority score, resampling, sequential Monte Carlo.

1. Introduction

Stochastic dynamic systems are widely used in fields such as physics, finance, and engineering, among others. One of the important tools used to study a complex dynamic system is to obtain Monte Carlo sample paths of the underlying stochastic process. Such samples can be used for statistical inferences under the Monte Carlo framework, and provide us with a better understanding of the behavior of the system. The sequential Monte Carlo (SMC) method is a class of efficient sampling methods that use the sequential nature of the underlying dynamic process (Gordon, Salmond and Smith (1993); Kong, Liu and Wong (1994); Avitzour (1995); Liu and Chen (1995); Kitagawa (1996); Kim, Shephard and Chib (1998); Pitt and Shephard (1999); Chen, Wang and Liu (2000); Godsill, Doucet and West (2004); Doucet and Johansen (2011)). Although the SMC method is often used to estimate the marginal distribution of the underlying state at each time point (either filtering or smoothing), it also naturally provides sample paths (with importance weights) of the joint distribution of the entire state sequence. Here, we focus on the problem of efficiently generating such sample paths in an SMC framework.

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