Research Skills for Computational Applied Mathematics

Matlab documentation

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1. Introduction

This project strictly follows [1]. The programming exercises are written in Matlab code available at `https://github.com/ZofiaTr/MCMC_SanzSerna`.

The main source code is located in folder "Matlab_code". The exercise tasks $1-6$ correspond to functions called "main+task_number+task_name ". Functions used in the main files are saved in folder "functions", which is linked by "addpath" comand at the beginning of each file. Figures are saved in folder "figures".

2. Metropolis Random Walk

2.a. Histogram

The source code is in "main1_sample_MetropolisRW.m". The simulation is described in [1][Section 5.3] and it reproduces [1][Figure 6].

2.b. Tasks

1. Fit the target density on the histogram, create plot of X^n over n steps.
2. Comment out the Metropolis step, and rerun the sampling only with the random walk proposal, create plot of X^n over n steps.

2.c. Autocorrelation

The source code is in "main2_sample_autocorrelation.m". The simulation reproduces [1][Figure 7].

2.d. Tasks

1. Implement auto-covariance function called "compute_empirical_auto_correlation_coeff" which takes array of samples X and lag and returns empirical auto-covariance computed according to the formula at the end of [1][Section 5.3].
2. Compare with the correlation obtained with Matlab's "autocorr" function and plot the results together.
3. Try out more values for the step size h.

2.e. Brownian motion

The source code is in "main3_BrownianMotion". The simulation reproduces [1][Figure 8].

2.f. Euler-Maruyama

The source code is in "main4_sample_EulerMaruyama". The simulation reproduces [1][Figure 9]. The method is described in [1][Section 6.3].

2.g. Tasks

1. Turn off the noise and compare with the exact solution for the corresponding ODE.
2. Following the simulation setting described in [1][Section 6.3], reproduce [1][Figure 10].

2.h. Comparison of Random-Walk Metropolis and MALA

The source code is in "main5_sample_comparisonMALAandRW". The simulation reproduces [1][Figures 11 and 12].

2.i. Comparison of Random-Walk Metropolis, MALA and HMC

The source code is in "main6_sample_comparison_RW_MALA_HMC". The simulation reproduces [1][Figures 14, 15 and 16].

References

[1] JM Sanz-Serna. Markov chain monte carlo and numerical differential equations. In *Current challenges in stability issues for numerical differential equations*, pages 39–88. Springer, 2014.