Subjects for Projects. Course "Stochastic methods in Mathematical Modelling". AY 2021-2022.

December 4, 2022

1 General information

Each student is required to select the topic (usually, an article) for a project. It is expected that a paper is carefully read and the main method/techniques and/or part of the results are reproduced with a purpose of understanding by doing. Then a concise but informative report should be produced in form of a pdf file. The report is expected to have a detailed description of the methods/techniques and reproduced results and highlight the understanding of the subject. The length of the report should not exceed 10 A4 pages.

The list of the topics is a list of suggestions rather than mandatory choices. Alternative proposals are appreciated if they reside within the scope of the course. These suggestions will require an approval by the course instructor though.

The topics have to be selected by the 7nd of December at the latest. Then the presentations will be organised on the 20th of December. The report will be expected on the 25st of December EOD.

The topics are distributed according to the first come, first serve principle. Each student takes 1 topic. Please, write me an email with your choice and in case there is a conflict of interest the earlier date of the email will be a criterion. In the case you cannot successfully retrive a paper yourself, please, write the course instructor.

N.B. The projects listed in italic script are the ones already taken!

2 List of topics

- Large deviations for metastable states of Markov processes with absorbing states with applications to population models in stable or randomly switching environment

  https://arxiv.org/abs/2107.05354

- Coarse graining of biochemical systems described by discrete stochastic dynamics

https://arxiv.org/abs/2102.13394

- Maximal Diversity and Zipf's Law

  https://arxiv.org/abs/2103.09143

  https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.127.128301

- Active Brownian Motion in two-dimensions under Stochastic Resetting

  https://arxiv.org/pdf/2008.03294.pdf

- Slice Sampling MCMC. Recommended review is Neal, Radford M. (2003). "Slice Sampling". Annals of Statistics 31 (3): 705767.

- Simulated Annealing Sampling. Important idea and algorithm allowing to explore seriously non-convex problems – rugged landscape with multiple valleys, saddle points, minima and peaks. The original paper is Kirkpatrick, S.; Gelatt Jr, C. D.; Vecchi, M. P. (1983). "Optimization by Simulated Annealing". Science 220 (4598): 671680.

- *Hamiltonian MCMC. MCMC which is capable to accelerate sampling by adding additional degrees of freedom - related to controlled inertia/momenta expressed through a Hamiltonian description (from physics) — thus the name.* Recommended review

  http://www.cs.utoronto.ca/radford/ftp/ham-mcmc.pdf

- *Irreversible Monte Carlo algorithms for efficient sampling*

  The original paper is www.arxiv.org/abs/0809.0916

- *Discrete sampling of extreme events modifies their statistics*

  Lior Zarfaty, Eli Barkai, and David A. Kessler

  https://arxiv.org/abs/2109.13038

- Sequential Monte Carlo for Importance Sampling and Inference

  Recommended paper www.irisa.fr/aspi/legland/ensta/ref/doucet00b.pdf

- Jackson Networks of Queues

  Recommended paper is Kelly, F. P. (Jun 1976). "Networks of Queues". Advances in Applied Probability 8 (2): 416432.

  See also https://en.wikipedia.org/wiki/Jackson_network and references there in. It may also be useful to consult with the recent book: "Stochastic Networks" by E. Yudovina and F. Kelly, Cambridge University Press, 2014. Implementation is especially encouraged.

- Stochastic Resonances

  Curious physics phenomena important in optics and communications which explains how noise/randomness allows to amplify signal and observe what otherwise would be difficult to detect. Recommended paper is Benzi, R.; Sutera, A.; and Vulpiani, A. "The Mechanism of Stochastic Resonance." J. Phys. A 14, L453-L457, 1981.

- *Multivariate stable distributions and their applications for modelling cryptocurrency-returns,*

  https://arxiv.org/abs/1810.09521

- *Collective Phenomena Emerging from the Interactions between Dynamical Processes in Multiplex Networks,*

  https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.118.138302

- Phenotypic Diversity, Population, Growth, and Information in Fluctuating Environments

  https://science.sciencemag.org/content/309/5743/2075

- On the generation of anomalous and ultraslow diffusion

  https://iopscience.iop.org/article/10.1088/1751-8113/44/40/405006

- The Noisy Channel Coding (Shannon) Theorem Sec. 9.3 and 10 of D. J. C. Mackay, Information theory, inference, and learning algorithms. Cambridge: Cambridge University Press, 2003. [Online]. Available: http://www.inference.phy.cam.ac.uk/itprnn/book.html

- Inhomogeneous parametric scaling and variable-order fractional diffusion equations https://arxiv.org/pdf/2004.09876.pdf

- Aging renewal theory and application to random walks

  https://arxiv.org/pdf/1310.1058.pdf

- Bayesian analysis of single-particle tracking data using the nested-sampling algorithm: maximum-likelihood model selection applied to stochastic-diffusivity data

  https://pubs.rsc.org/–/content/articlelanding/2018/cp/c8cp04043e/#!divAbstract

- Anomalous Metapopulation Dynamics on Scale-Free Networks

  https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.118.098301

- Brownian yet Non-Gaussian Diffusion: From Superstatistics to Subordination of Diffusing Diffusivities

  https://journals.aps.org/prx/pdf/10.1103/PhysRevX.7.021002

- Adsorption-Desorption Kinetics of Soft Particles

  https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.115.088301

- Quantifying information for a stochastic particle in a flow-field

  https://arxiv.org/pdf/1911.00693.pdf

- Reinforcement Learning with Replacing Eligibility Traces

  Satinder P. Singh and Richard S. Sutton, Machine Learning, volume 22, pages 123–158 (1996)

- Regress-Later Monte Carlo for optimal control of Markov processes

  https://arxiv.org/abs/1712.09705

- *First-passage times and normal tissue complication probabilities in the limit of large populations*

  Peter G. Hufton, Elizabeth Buckingham-Jeffery and Tobias Galla, Sci. Rep., 10, 8786 (2020)

  https://www.nature.com/articles/s41598-020-64618-9.pdf

- *Unreasonable effectiveness of learning neural networks: From accessible states and robust ensembles to basic algorithmic schemes*

  https://www.pnas.org/content/113/48/E7655

- An application of the Widom insertion formula to transition rates in a lattice

  https://journals.aps.org/pre/abstract/10.1103/PhysRevE.104.044104

  https://arxiv.org/abs/2107.06765