Project proposals

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This document presents different work avenues the author wishes to pursue as a final project for an Applied Probability Models course. Each section represents one such avenue, in which the justification for choosing such project is given.

1 Epidemic modeling

The modeling of infectious diseases is of upmost importance, as can be appreciated greatly these days. In this project, we pretend to study the stochastic spread of a contagion process. Questions that can be addressed by these studies include: What is the probability of a major outbreak? How long is the disease likely to persist? [Britton, 2010]. Both theoretical and computational results are to be presented in an attempt to bring light to these questions.

2 Random graphs

Networks arise in many scientific and technological fields [Newman, 2018]. The internet, social networks, electrical networks, are among many available examples. To study network processes, sometimes it is convenient to have a model which preserves the essential characteristics of the network. A random graph is a model network in which the values of certain properties are fixed, but the network is in other respects random [Newman, 2018]. For example, a number n nodes and m edges could be fixed, but edges between any two nodes placed at random. The aim of this project is to do a theoretical and computational study of random graphs, and analyze how closely some of these resemble real world networks [Leskovec and Krevl, 2014].

3 Community detection

The problem of finding clusters or communities in graphs is omnipresent in data mining [Alamgir and von Luxburg, 2010]. Several approaches to finding these communities involve the use of probabilistic models, such as random walks [Alamgir and von Luxburg, 2010, Pons and Latapy, 2005, Lambiotte et al., 2014, Zhang et al., 2018] or stochastic block models [Schaub and Peel, 2020]. In these project, the goal is to implement some of these methods in real world networks [Leskovec and Krevl, 2014].

4 Stock pricing models

The random-walk hypothesis states that a random walk model provides a good explanation of the variation of stock market prices [Godfrey et al., 1964]. In this project, we will explore some of these models, such as the geometric Brownian motion model [Dunbar], and compare it to the performance of real world stocks.

References

M. Alamgir and U. von Luxburg. Multi-agent random walks for local clustering on graphs. page 18–27, Dec 2010. doi: 10.1109/ICDM.2010.87. URL http://ieeexplore.ieee.org/document/5693955/.

T. Britton. Stochastic epidemic models: A survey. *Mathematical Biosciences*, 225(1):24–35, May 2010. ISSN 00255564. doi: 10.1016/j.mbs.2010.01.006.

S. R. Dunbar. Stochastic pocesses and advanced mathematical finance. Models of stock market prices. https://www.math.unl.edu/~sdunbar1/MathematicalFinance/Lessons/StochasticCalculus/StockMarketModel/stockmarketmodel.pdf.

M. D. Godfrey, C. W. J. Granger, and O. Morgenstern. The random-walk hypothesis of stock market behavior. *Kyklos*, 17(1):1–30, Feb 1964. ISSN 0023-5962, 1467-6435. doi: 10.1111/j.1467-6435.1964.tb02458.x.

R. Lambiotte, J.-C. Delvenne, and M. Barahona. Random walks, markov processes and the multiscale modular organization of complex networks. *IEEE Transactions on Network Science and Engineering*, 1(2):76–90, Jul 2014. ISSN 2327-4697. doi: 10.1109/TNSE.2015.2391998. arXiv: 1502.04381.

J. Leskovec and A. Krevl. SNAP Datasets: Stanford large network dataset collection. http://snap.stanford.edu/data, June 2014.

M. Newman. *Networks*, volume 1. Oct 2018. ISBN 978-0-19-880509-0. doi: 10.1093/oso/9780198805090.001.0001. URL https://oxford.universitypressscholarship.com/view/10.1093/oso/9780198805090.001.0001/oso-9780198805090.

P. Pons and M. Latapy. Computing communities in large networks using random walks (long version). *arXiv:physics/0512106*, Dec 2005. URL http://arxiv.org/abs/physics/0512106. arXiv: physics/0512106.

M. T. Schaub and L. Peel. Hierarchical community structure in networks. 2020. URL https://arxiv.org/abs/2009.07196.

W. Zhang, F. Kong, L. Yang, Y. Chen, and M. Zhang. Hierarchical community detection based on partial matrix convergence using random walks. *Tsinghua Science and Technology*, 23(1):35–46, Feb 2018. ISSN 1007-0214. doi: 10.26599/TST.2018.9010053.