Proposal: Small-World Behavior in Time-Varying Interaction Networks of Mobile Agents

Will Vining

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1 Introduction

This paper will investigate the emergence of small-world behavior in time-varying graphs that represent the interactions between mobile agents. This builds on the work of Tang et al [3] who modeled time-varying interaction networks for agents moving in a finite space and periodically making large jumps to a distant location. I intend to model a more physically plausible scenario where agents cannot be "teleported" in this way. I will investigate whether small-world behavior emerges without "teleportation," and if so how many agents are required for the interaction network to exhibit this behavior. I will also investigate whether the properties of the interaction network change if agents employ different motion rules. Finally, I will examine communicability over these time-varying graphs using the method presented by Casteigts et al. [2].

2 Computational Methods

A model of agents moving in a finite space will be used to generate time-varying interaction networks. Agent movement will be continuous, and agent positions will be sampled a total of T times at a fixed rate to determine the interaction network at each time-step. As in [3] an edge will be added between agents at time t if they are within some fixed distance d of each-other. For ease and simplicity agents will be modeled as particles and collisions will not be considered. I will implement the "teleportation" movement described in [3] as well as Brownian motion, a Lévy flight, and a correlated random walk.

3 Experimental Methods

I will use the agent-based model described in section 2 to generate 10 interaction networks for 10, 100, 1000, and 10000 agents and each type of motion (Teleportation, Brownian motion, Lévy flight, and Correlated Random Walk) for a total of 160 networks. Due to time constraints I will select some reasonable fixed parameters for each random walk (keeping the speed of the agents the same for all types of motion). For each network I will compute the metrics presented by Tang et al. [3] and Grindrod et al. [2]. To validate the results I will generate a series of ER graphs [1] corresponding to each interaction network. Each time-step in the original network will be replaced by an ER graph with the same number of edges as the original graph in that time-step. I will compute the same metrics for each of these interaction networks to determine if the observed behavior can be attributed to random chance and the number of interactions, or if it depends on the motion of the agents.

References

[1] Erdös, P., and Rényi, A. On the evolution of random graphs. *Publ. Math. Inst. Hung. Acad. Sci 5* (1960), 17–61.

[2] Grindrod, P., Parsons, M. C., Higham, D. J., and Estrada, E. Communicability across evolving networks. *Physical Review E 83*, 4 (apr 2011), 046120.

[3] Tang, J., Scellato, S., Musolesi, M., Mascolo, C., and Latora, V. Small-world behavior in time-varying graphs. *Physical Review E 81*, 5 (may 2010), 055101.