

The thesis of Mr. Sumeet Agarwal combines network science, biology, and machine learning in a seamless way, making a very strong and timely contribution to this multidisciplinary area. The overall scientific quality of the thesis is excellent, and the thesis is extremely well written. The examiners were of the opinion that the work contained in the thesis can be published in scientific journals of the highest quality, and indeed parts of the thesis have already been published.

Chapter 1 starts with a brief statement about the history of graph theory, the predecessor of network science, placing the work in a broader context. It then proceeds by introducing the basic network concepts, and covers several network diagnostics and summary statistics in detail.

Chapter 2 deals with protein interaction networks. It covers some introductory biological material, and does this in a reader-friendly way. It then introduces the major data sets in this field of research, and discusses the measures that can be used to characterize topological communities and their relationships to the functional organization of protein interaction networks. The chapter proceeds by revisiting the notion of "date hubs" and "party hubs," concepts that were introduced a few years ago in a very influential article published in Nature, finding that some of the conclusions of the original paper, as well as some subsequent studies, were not fully supported by data.

Chapter 3 introduces the idea of high-throughput analysis of networks. The approach, which has its basis in machine learning, essentially consists of taking a very large collection of networks, both empirical and synthetic, and computing a very large number of different network measures and characteristics for each network. Perhaps the main finding is that one can cluster networks remarkably well by using just the first two principal components of the underlying design matrix. The chapter then employs various network features to learn about the nature of the solution to the traveling salesman problem (TSP) on various networks. The chapter ends with an interesting section on phylogeny regression, where the idea is to explore the changes in networks of interacting pathways over the course of evolution.

Chapter 4 examines patterns of correlations between different network features. Although presented as exploratory work, the approach is actually very interesting in that it enables one to get a sense of the variability within network categories, e.g. how variable social networks or brain networks are, but also, importantly, what are the main differences across these categories.

Chapter 5 deals with two different notions of entropy, and investigates the nature of their correspondence with one another. This section features some interesting analytical calculations, with the details (rightly so) deferred to the Appendix. The main finding of the chapter is that the two notions of entropy employed are actually quite different, at least for the studied systems, and hence one cannot be used as a substitute for the other.

Chapter 6 follows pushes some of the earlier ideas further by incorporating ideas from the Bayesian paradigm. This is very appealing, as in the Bayesian context one can (indeed, has to) be transparent about the modeling assumptions in the sense that one needs to explicitly specify prior distributions for the parameter(s) of interest. It is surprising how little has been done in the intersection of networks and Bayesian modeling, and this chapter of the thesis clearly demonstrates what may be gained from combining the two.

Mr. Agarwal was very thoughtful and clear in his responses to the questions presented to him during the 4.5-hour examination. He obviously had a very deep understanding of the topic, which enabled him to provide very detailed answers. In addition to mastering the technical details, he also had a clear perception of where his work falls in the broader scientific context.

Overall, the examiners regarded the thesis and its defense as excellent and are happy to recommend award of the D.Phil.