Course on the Mathematics and Algorithms of Social Networks

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1 Course Description

Social networks are useful in a wide range of areas in our lives, from job hunting to marketing and politics. In this course, we will study social networks from both aspects of practice and theory. The course will be divided into three parts, the first will contain advanced standard mathematical materials from the theory of social networks. The second part will present cutting edge recent advance papers in social networks, presented by leading researchers in the field. The third part will study recent developed fascinating connections between social networks and masterpiece plays.

For the theoretical part, we will concentrate on models that describe reality and the structure of social networks. We will try to understand what those models predict and how those models connect to our lives. From a practical point of view, we will learn how to gather data and how to analyze this data once we acquire it. The course will have 10 topics. For each topic there will be exercises that will help the student learn. The course is geared towards graduate students interested in social networks and algorithms.

2 Course Goals and Objectives

The student will learn the theory of social networks and algorithms related to this subject. We will also help students who are interested in social networks conduct their own research in social networks.

At completion of the course, the student should know the following subjects:

1. 5/11/2016-Introduction to networking and Random network models: Erdos-Renyi, the preferential attachment model and other models.

2. 12/11/15- Power law, real networks and real data.

3. 19/11/15-Six degrees of separation and models of small-world networks- Invited speaker Prof. Pierre Fraigniaud from CNRS, Paris Diderot

4. 26/11/15- Network Centrality- Invited speaker pilu (Prof. Pierre Luigi Crescenzi)

5. 3/12/15- Core-periphery model.

6. 10/12/15- Networks densification and shrinking diameter- Invited speaker Prof. Claire Mathieu from cole Normale Suprieure, Paris, France; and Prof.Zvi Lotker.

7. 17/12/15- No Lecture this week.

8. 7/1/16- Glass ceiling and minority vs majority- Invited speaker Prof. Chen Avin, Ben Gurion University, Israel. ?

9. 14/1/16- Election and social networks- The case of *Julius Caesar* by William Shakespeare

10. 21/1/16- Time in social networks- through theater plays

11. 28/1/16- Psychology and social networks through theater, and final conclusion

2.1 Introduction to networking, Random network models 5/11/2016

In this lecture we will concentrate on what networks are, how to represent them and where we find them in our lives. We will meet several stochastic models that allow us to generate a wide variety of networks. We will study the basic properties of each stochastic model and where we use them and what the differences are between those models.

2.2 Real networks and real data 12/11/15

In this lecture we will study how to obtain data from real networks such as facebook, linkedIn, Google+, and other data sets that are available on the web. This is extremely important for verifying our models and claims. We will also demonstrate how to fit data into the models that were presented in the previous lecture.

2.3 Six degrees of separation and models of small-world networks 19/11/15

In this lecture Invited speaker Prof. Pierre Fraigniaudwe will discuss several characteristics of social networks including Milgram's experiment on the six degree of separation and we will present Kleinberg's model which tries to explains Milgram's experimental results.

2.4 Network centrality 26/11/15

The lecture will be formed by two parts. In the first part, Prof. Pierre Luigi Crescenzi will talk in general about the notion of centrality, and the different mathematical definitions that have been introduced and analyzed when dealing with graphs. In the second part, Prof. Crescenzi will focus on the closeness centrality, and will talk about a new method for computing the top-k closeness centralities, which will be analyzed, both from an experimental and a probabilistic point of view.

2.5 Core-periphery model 3/12/15

Core-periphery models are appearing in many science disciplines such as city planning, biology and social networks. In this lecture we will present a model for core-periphery in social networks. We will also discuss several experiments that support this model. We will use these models to derive some conclusions about our daily lives. The basic question we will try to understand is what the proportions are of the core compared to the periphery. This can be used as a rule of thumb to understand our place in society. Instead of using an evolutionary model, we will use the axiomatic approach to understand the core-periphery phenomenon.

2.6 Networks densification and shrinking diameter 10/12/15

In this lecture we will consider the universal properties of densification and shrinking diameter. The lecture will be composed of two parts: the first will concentrate on the universal properties of densification and the connection between densification and a non-linear core. The second part will present the shrinking diameter in the forest fire model. The first part will be presented by Prof. Zvi lotker and the second part by Prof. Claire Mathieu

2.7 Glass ceiling and minority vs majority 7/1/16

The relationship between minority and majority is a focal question in the social sciences. In this lecture we will present a simple model that allows us to study the interaction of power between the minority and

the majority. This model shows that once there is an unbalanced population, together with homophily (self-interest), the glass ceiling effect will naturally appear.

2.8 Election and social networks- The case of *Julius Caesar* by William Shakespeare 14/1/16

In this lecture, we will study how to use social networks in order to analyze political elections. We will talk about the problem of validation and soundness of algorithms in social networks. We will use William Shakespeare to solve some of those problems.

2.9 Time in social networks- through theater plays 21/1/16

In this lecture we will discuss the meaning of time in Social networks, and how to compare two time dimensions. We will develop mathematical algorithms that use the notion of time to compute social interactions between nodes through time. We will use theater as a case study, mainly William Shakespeare's.

2.10 Psychology and social networks through theater 28/1/16

When studying social network, it is sometimes desired to know, or guess, what members of the society think, how do they perceive themselves and others. In this lecture we will discuss those question, and present some algorithmic tools, which allowed us to answer part of those questions in a theater network.