Master Thesis Subjects (Academic Year 2020-2021)

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Project 1: Detecting the infection source of epidemic outbreaks

Background: Infections such as COVID-19 or HIV spread through networks of contacts between individuals. Finding the patient zero of an epidemic outbreak is fundamental because it helps to understand how a bacteria or virus was introduced and to trace transmission trees in the population. The social networks in which infections spread are typically dynamic because individuals interact with different people over time.

Aim: The aim of this project is to develop and study the effectiveness of an algorithm to detect the source of simulated infections on real-world time-evolving contact networks. The goals are thus to computationally implement toy models of epidemic spread on real time-evolving contact networks and methods to identify the source of infections, and analyse the effectiveness of this method applied to real-world network data.

Skills: The student will develop skills in complex systems, network science, network epidemiology, and computational modelling. The student will be associated to the Complex Systems Institute at UGent (www.csi.ugent.be).

Pre-requisites: Background in quantitative sciences, e.g. Physics, Economics, Engineering, Computer Science. Interest in complex systems and network science (no previous experience required). Programming skills in C/C++, or Python, or Java (or other equivalent high-performance programming language).

Reference: LEC Rocha, N Masuda (2016) Individual-based approach to epidemic processes on arbitrary dynamic contact networks. *Sci Rep* **6** 31456. https://doi.org/10.1038/srep31456

Project 2: Opinion dynamics on social networks

Background: Individual opinions are formed via self-reflection and interactions with other people. We are all immersed in social networks and thus constantly exposed to opinions of friends, co-workers and relatives. This means that our social context influence our behaviour and opinions. The increasing engagement with social media implies that our opinions are shaped by online posts, e.g. on Facebook or Instagram. However, many people are stubborn and does not change opinions easily.

Aim: The aim of this project is to study opinion formation on complex social networks to better understand the role of social networks on the emergence of polarisation and extremism in society. The goals are thus to design and simulate toy models of opinion dynamics with stubborn actors on theoretical and real-world social networks to analyse the interplay between individual resistance to change and network structure in the evolution of two competing opinions.

Skills: The student will develop skills in complex systems, network science, opinion dynamics, and computational simulation of agent-based models. The student will be associated to the Complex Systems Institute at UGent (www.csi.ugent.be).

Pre-requisites: Background in quantitative sciences, e.g. Physics, Economics, Engineering, Computer Science. Interest in complex systems and network science (no previous experience required). Programming skills in C/C++, or Python, or Java (or other equivalent high-performance programming language).

Reference: N Perra, LEC Rocha (2019) Modelling opinion dynamics in the age of algorithmic personalisation. *Sci Rep* **9** 7261. https://doi.org/10.1038/s41598-019-43830-2

Project 3: Global migration of sex-workers

Background: The socio-economic environment of a country may promote the engagement of women in commercial sex-work. In search for financial gains, some women in this business migrate between different countries and advertise their services using online ads. The migration patterns may reveal socio-economic distortions between countries and online ads may provide insights into sex-work business, in particular, related to sexual behaviour and economics.

Aim: The aim of this project is to perform an explorative study of a large global data set of sex-worker migration. The goals are thus to measure network structures, analyse the available meta-data (e.g. compare prices across countries), find patterns, make correlations with socio-economic indicators, and potentially find links with other trade and migration networks.

Skills: The student will develop skills in network science, data analysis, basic text-processing. The student will be associated to the Complex Systems Institute at UGent (www.csi.ugent.be).

Disclaimer: This data set includes information about sexual behaviour of anonymous individuals. The student will sign a non-disclosure agreement and engage in ethical and serious scientific analysis of the data. This is a purely scientific, no judgemental, study.

Pre-requisites: Background in quantitative sciences, e.g. Physics, Economics, Engineering, Computer Science. Interest in network and data science (no previous experience required). Programming skills in Python, or R, or C/C++ (or other equivalent programming language).

Reference: LEC Rocha, F Liljeros, P Holme (2010) Information dynamics shape the sexual networks of Internet-mediated prostitution. *PNAS* **107** 5706
https://www.pnas.org/content/107/13/5706