Supervisor: Felicia Magpantay and Troy Day

Project Description: During an epidemic the emergence of "variants of concern" is shaped by evolutionary pressures such as vaccination and competition. The pandemic has led to an explosion in genomic surveillance, highlighting the need for efficient and mathematically rigorous analysis of epidemiological time series coupled with genetic data. In this project we will look into the recently developed theory of Markov genealogy processes. We will also examine the implementation of this theory for statistical inference in the R package phylopomp and apply it to datasets.
Main reference: https://doi.org/10.1016/j.tpb.2021.11.003

Student's Role The student will participate in our study of Markov genealogy processes and conduct a review of different approaches in phylodynamic analysis. The student will also learn about phylopomp and high-performance computing, and apply these to a disease modeling

- (i) Optimal stochastic control with partial information: Non-linear filtering, approximations, and relations with reinforcement learning
- (ii) Multi-agent systems, stochastic teams, and games: Arriving at optimality/equilibrium under decentralized information
- (iii) Sample complexity in such learning algorithms

Project Title: Pinning Stabilization of Complex Networks: Using Event-Triggered Impulses

Supervisor: Kexue Zhang

Project Description: Complex networks (CNs) consist of vast nodes typically modelled as dynamical systems, with specific topological structures governing their connections. Impulsive control, a distinctive feedback control, employs abrupt state changes or jumps at discrete time intervals to achieve stabilization. This impulsive control paradigm has demonstrated robustness and efficiency in facilitating network stabilization. In this project, we will investigate stabilization problems for CNs using pinning impulsive control approaches, where only a subset of the network nodes is controlled. We will explore novel event-triggering algorithms to identify the timing for impulses, and then construct sufficient conditions related to the network topology, impulsive control gains, and parameters in the event-triggering conditions that ensure network stabilization.

Student's Role: Study various stability notions and stability results for continuous-time systems and systems with impulses; explore the application of stability results for systems with impulses to event-triggered impulsive control of complex networks. Conduct numerical simulations to verify the impulsive stabilization process for complex networks.

Prerequisites

Student's role: The student is expected to do a literature review, understanding existing R codes, implement some methods in R, building a R package and writing a documentation. The student will gain a deeper understanding of statistical concepts, modeling, and become expertise in R programming. The student will be the author of the R package and an article sent to Journal of Statistical Software.

Prerequisites (req'd background/level of study): Be familiar with R, have a strong background in computing and statistics.

Project Title Quotients of root systems of infinite Coxeter groups and inversion sets

Supervisors Ivan Dimitrov, Charles Paquette and David Wehlau

Project Description: The group of permutations on n letters is ubiquitous in mathematics and is the simplest example of a Coxeter group. Coxeter groups are groups generated by reflections
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