PhD Seminar Talk-II

Analysis and Simulations of Network-Based Nonlinear Epidemic Models

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Abstract: In this seminar talk, our focus is on the Susceptible-Exposed-Infected-Removed (SEIR) type epidemic model, which is divided into two parts.

⋆ ***Hopf bifurcation analysis of SEIR-type model***: Hopf bifurcation in epidemiology plays a crucial role in understanding the dynamics of infectious diseases within populations. It helps explain how infectious diseases can exhibit oscillatory patterns within a population. Instead of disease prevalence following a simple exponential growth or decline, it can oscillate, leading to periodic outbreaks. This phenomenon is observed in diseases like measles, whooping cough, and seasonal flu. To examine this phenomenon, we conduct an extensive study on a delayed SEIR epidemic model posed on a discrete medium comprising networks of population clusters. This model captures population mobility in the network via graph Laplacian diffusion and measures spread of infection with a non-linear incidence rate incorporating the natural delay phenomena. We demonstrate local stability for each steady state and explore the existence of Hopf bifurcation at the endemic equilibrium. Making use of Normal Form Theory and Center Manifold Theorem, we ascertain the direction of the bifurcation. Finally, we present visual illustrations of our theoretical findings via computational experiments on a small-world Watts-Strogatz graph.

⋆⋆ ***Stability analysis of a Caputo-based fractional-order SEIR-type model***: It has been observed that fractional-order models and fractional-order modeling of dynamical, biological, and physical systems involve more degrees of freedom and longer-range interactivity in time. Most ecological, biological, physical, and engineering systems exhibit long-range temporal memory. Modeling such systems using fractional-order differential equations offers more advantages than classical integer-order mathematical modeling, which neglects the effects of temporal memory. A Caputo-based fractional-order SEIR epidemic model is employed, utilizing graph Laplacian diffusion on a weighted network. The model's existence and uniqueness have been established, and both local and global stability for each steady state have been thoroughly investigated. The numerical results, presented on a small-world network, justify the theoretical findings.