香港浸會大學理學院
HKBU Faculty of Science

DEPARTMENT OF COMPUTER SCIENCE

PhD Degree Oral Presentation

PhD Candidate:	Mr. REN Jinfu
Date	22 August 2023 (Tuesday)
Time:	2:30 pm – 4:30 pm (35 mins presentation and 15 mins Q & A)
Venue:	1) DLB637, 6/F, David C Lam Building, Shaw Campus 2) ZOOM (Meeting ID: 947 7913 8230) (The password and direct link will only be provided to registrants)
Registration:	https://bit.ly/bucs-reg (Deadline: 6:00 pm, 21 August 2023)

Machine Learning for Characterizing the Dynamics of Complex Systems: Methods and Applications

Abstract

Complex systems are composed of multiple interconnected, interacting, and interdependent components and subsystems, and are often encountered in real-world scenarios. Modeling and understanding the dynamics of complex systems is a scientific challenge and a practical opportunity because such efforts enable professionals to gain insights into how systems' dynamical behavior evolves over time and thereby inform their strategies and decisions.

Model-based methods (i.e., simulations) are commonly adopted to represent certain behavioral features of complex systems based on predefined governing rules and/or parameterized equations. However, these methods can be very sensitive to model settings because of the high dependence of a complex system's dynamical behavior on its initial conditions and parameters. Furthermore, the governing rules are too complex to be unambiguously specified in reality.

Instead of predefining models, data-driven methods, as an alternative, learn models from data: they understand the underlying relationships within complex systems by analyzing observations of their input and output (e.g., from historical data of a system's behavior). Nevertheless, fundamentally challenges still exist due to three key problems:

1. How can we quantitatively model the interactions and interdependencies of multiple components of complex systems?
2. How can we appropriately represent and capture the dynamics of complex systems when we have only partial observations of the systems' behavior?
3. How can we accurately characterize the aperiodic, irregular, or even chaotic behavior of complex systems?

We answer these questions in a systematic way by developing, analyzing, and demonstrating three innovative machine-learning methods in the contexts of epidemiology and climatology:

1. We devise a physics-integrated learning method for an epidemiological scenario by quantifying the interdependencies of various components of complex systems using human mobility data from different locations to construct a dynamical network between components/sub-systems (i.e., metapopulations). We verify the effectiveness of the method by applying it to healthcare resource allocation.
2. We devise a deep transfer learning method for an epidemiological scenario. This method learns epidemic dynamics in data-limited regions (i.e., target domains) by transferring useful information from a data-rich region (i.e., source domain). We theoretically demonstrate the adaptability of the method and empirically demonstrate its effectiveness.
3. We devise a method denoted 'Information-Tracking' for learning a climatological scenario. This method tracks and adapts to chaotic changes in a system's behavior by utilizing a probabilistic feedback mechanism to the forecast error of the next time step based on the current forecast. We provide a comprehensive theoretical analysis to guarantee the capability of the method to characterize the chaotic behavior and illustrate its effectiveness in processing synthetic datasets and performing the real-world task of decadal temperature prediction.

***** ALL INTERESTED ARE WELCOME *****