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Beiyu Lin

The University of Texas Rio Grande Valley

Xiaowei Jia

Zhiqian Chen

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Beiyu Lin* Xiaowei Jia† Zhiqian Chen‡

Abstract

The current COVID-19 epidemic have transformed every aspect of our lives, especially our behavior and routines. These changes have been drastically impacting the economy in each region, such as local restaurants and transportation systems. With massive amounts of ambient data being collected everywhere, we now can develop innovative algorithms to have a much greater understanding of epidemic spread patterns of COVID-19 based on spatiotemporal data. The findings will open up the possibility to design adaptive planning or scheduling systems that will help preventing the spread of COVID-19 and other infectious diseases.

In this tutorial, we will review the trending state-of-the-art machine learning techniques to model epidemic spread patterns with spatiotemporal data. These techniques are organized from two aspects: (1) providing a comprehensive review of recent studies about human routine behavior modeling, such as inverse reinforcement learning and graph neural network, and the impacts of behaviors on the spread patterns of infectious diseases based on GPS data; (2) introducing the existing literature on using remote sensing data to monitor the spatiotemporal pattern of the epidemic spread. Under current epidemic with unknown lasting time, we believe that modeling the spread patterns of COVID-19 epidemic is an important topic that will benefit to researchers and practitioners from both academia and industry.

Keywords epidemic spread pattern, spatiotemporal data

1 Target Audience

Our target audience includes all levles researchers and practitioners in spatiotemporal data mining and Epidemic spread modeling. The prerequisites for this tutorial are calculus, linear algebra, and machine learning. We plan to cover half of the materials for beginners and the rest for intermediate and experts. We expect the audience to come away with an overview of the state-of-art models of Epidemic spread based on spatiotemporal data. While knowledge in reinforcement learning, spatio-temporal data mining, neural graph network will facilitate a deeper understanding of Epidemic spread, the tutorial can be digested without any existing knowledge of those models.

*University of Texas Rio Grande Valley.
†University of Pittsburgh.
‡Mississippi State University.

2 Tutors

Beiyu Lin, Department of Computer Science, University of Texas - Rio Grande Valley, email: beiyu.lin@utrgv.edu.

Xiaowei Jia, Department of Computer Science, University of Pittsburgh, email: xiaowei@pitt.edu.

Zhiqian Chen, Department of Computer Science, Mississippi State University, email: zchen@cse.msstate.edu.

3 Biography of Tutors

Dr. Beiyu Lin is an Assistant Professor in Computer Science at the University of Texas Rio Grande Valley. She constructs computational models based on ambient data to identify people's routine behavior patterns and assess their behavior changes; she also develops algorithms to apply these findings to diverse areas. The impact of her multi-disciplinary research collaborations has been reported in multiple publications. Beiyu has received several honors and awards, including second place for the 3-Minute Thesis Competition in the Voiland College of Engineering & Architecture. The recipient of several external scholarships, Beiyu has also been actively serving the computer science community (*in-person presenter and contributor*).

Dr. Xiaowei Jia is an Assistant Professor in the Department of Computer Science at the University of Pittsburgh. His primary research interest is on building deep learning models for modeling spatiotemporal data. A major highlight of his research is on combining machine learning methods and traditional mechanistic/physics-based models to capture complex spatio-temporal processes in scientific applications. His work has been published in major data mining and AI journals (e.g., TKDE) and conferences (e.g., SIGKDD, IJCAI, ICDM, SDM, and CIKM), as well as top-tier journals in hydrology (e.g., WRR) and agronomy (e.g., Agricultural Economics). Dr. Jia was the recipient of UMN Doctoral Dissertation Fellowship (2019), the Best Conference Paper Award in ASONAM 16, and the Best Student Paper Award in BIBE 14 (*in-person presenter and contributor*).

Dr. Zhiqian Chen is an Assistant Professor in the Department of Computer Science and Engineering at Mississippi State University. Dr. Chen has extensive experience in graph machine learning and applications. Most of them are published at top journals or conferences including Nature Communication, Storage EnergyMaterial, AAAI, IJCAI, IEEE ICDM, EMNLP. He also served as reviewer for prestigious journals and conferences like AAAI, NeuralPS, SIGKDD, SIGIR, IEEE TKDE and Geoinformatica. He also has rich experience in cooperation with domain experts, including Automated Music Composition, Circuit Deobfuscation, MaterialDiscovery. He received an outstanding contribution award from Toyota Research North America 2016 (*in-person presenter and contributor*).

4 Outline

Part 1: Behavior modeling via inverse reinforcement learning for based on spatiotemporal data(35 minutes)

We introduce algorithms, such as inverse reinforcement learning, that model human routine behavior based on ambient data (e.g., GPS data) [1, 2, 3]. We present the models of behavioral norms under the current or transferred environment and its impacts on Epidemic spread. The results will also help researchers in the fields of sociology, psychology, and anthropology to align their theories more closely with actual human behavior and Epidemic spread.

- Current challenging of behavior modeling (5 min)
- The properties of spatiotemporal data from ambient sensors (5 min)
- An data-driven approach, inverse reinforcement learning, models behavior patterns (20 min)
- Behavior patterns and its impacts on Epidemic spreads (5 min)

Part 2: Monitoring the spatio-temporal pattern of the Epidemic spread using remote sensing data. (35 minutes)

Remote sensing data are often collected over large regions at a regular time interval, and thus have a spatio-temporal nature. We will extensively discuss the possibilities of using machine learning techniques to discover complex spatio-temporal patterns for Epidemic spreads from remote sensing data [4, 5]. We will also introduce future directions in combining machine learning models with traditional mathematical models to model Epidemic spreads [6].

- The spatio-temporal nature of remote sensing data and the available data sources (5 min)
- The promise of deep learning on remote sensing (5 min)
- Existing works on using remote sensing for modeling the Epidemic spread (10 min)
- Existing works on using remote sensing for understanding human activities during the Epidemic spread (10 min)
- Discussion of future works on combining mathematical models with ML models the modeling the Epidemic spread (5 min)

Part 3: Epidemic spread forecast and contagion source locating based on spatiotemporal data (35 minutes)

Graph neural networks is a fresh tool on the problem of Epidemic analysis [7, 8]. We will cover an overview of graph neural networks for spatio-temporal modeling, followed by a discussion of spread forecasting and source locating. Graph neural networks characterizes Epidemic transmission with message passing mechanisms by identifying the possible propagation directions and recovering sources. We will also discuss future directions of applying graph neural network on Epidemic modeling.

- Modeling Epidemic spread with spatio-temporal graph (10 min)
- Epidemic spread forecast (10 min)
- Contagion source locating (10 min)
- Future work on Epidemic spread via graph learning(5 min)

Conclusion and Discussion (10 minutes)

- Conclusion (5 minutes)
- Q & A (5 minutes)

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