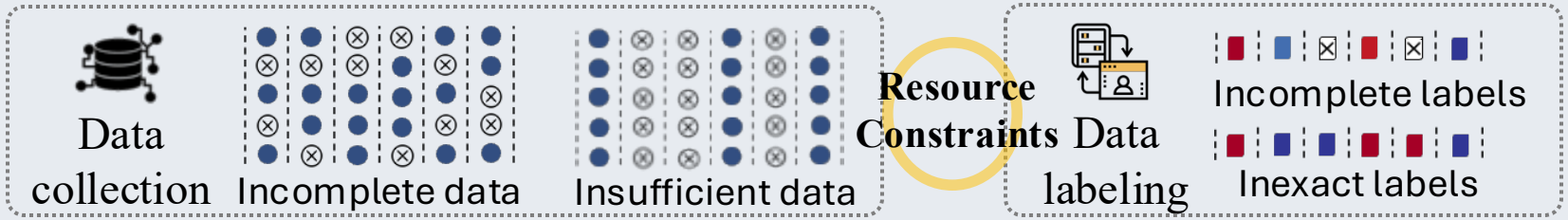
Research summary

Motivation

- Data structural complexity
- Limited availability of high-quality data (referred to as ***weak supervision***)



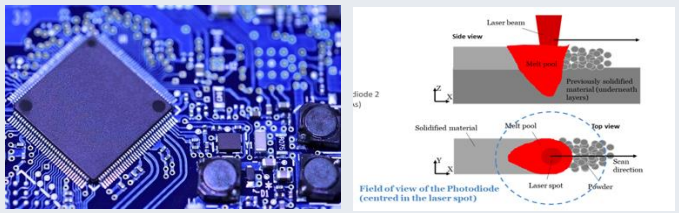
Methodology

Advanced statistics & machine learning techniques

Clinical & engineering domain knowledge

Applications

Healthcare
(e.g., sleep disorders, infectious diseases)



Manufacturing
(e.g., additive manufacturing)

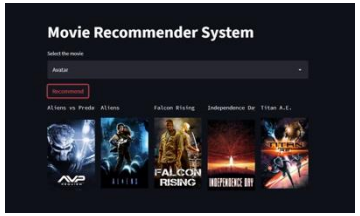
Service
(e.g., recommender)

Contact: xin-zan@uiowa.edu

Topic I: Causality-aware social recommender systems

Objective

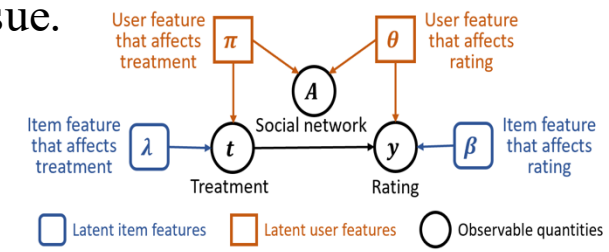
- To take an explicit causal view of the social recommendation and leverage social network structure to enhance the recommendation.



Example of a movie recommender system

Methods

- Multiple causal inference for social recommendation to mitigate confounding bias subject to missing-not-at-random (MNAR) issue.
- Incorporating social network into matrix factorization models through regularization.



Results

- Higher accuracy of rating prediction compared with baseline methods.

Case	U	I	γ	Proposed method	Baseline causal	Baseline social	Baseline MF
1	500	300	0.25	220405.80 (1582.78)	226931.79 (1603.01)	566944.09 (5986.16)	299929.08 (2212.17)
2	500	300	0.50	181011.85 (1203.96)	186627.70 (2086.40)	419039.09 (6129.09)	275144.58 (2616.59)
3	500	300	0.75	127004.22 (1737.05)	129910.15 (1504.19)	235571.55 (4287.63)	218952.41 (3057.33)
4	1000	500	0.25	750757.23 (3168.30)	825478.07 (46306.61)	1851029.96 (14175.96)	997352.56 (6714.66)
5	1000	500	0.50	613548.22 (3968.54)	640818.56 (5677.98)	1402243.47 (8784.54)	901936.71 (5551.28)
6	1000	500	0.75	423342.96 (2656.22)	467422.42 (15171.00)	791481.94 (6618.24)	699890.07 (2530.15)
7	1000	1000	0.25	1589628.94 (8396.48)	1696991.28 (28642.80)	3679919.31 (23497.18)	1778072.68 (12289.80)
8	1000	1000	0.50	1296950.39 (4727.49)	1417450.56 (35121.64)	2786414.24 (17638.51)	1596245.92 (8867.34)
9	1000	1000	0.75	911063.78 (4397.34)	1008394.23 (22604.55)	1591736.22 (11429.37)	1205535.96 (4396.50)

Summary

- Proposed a causality-aware social recommender with network homophily informed multi-treatment confounders to mitigate the confounding bias from networked observed rating data.
- Validated by simulated and real datasets to achieve higher rating prediction accuracy.

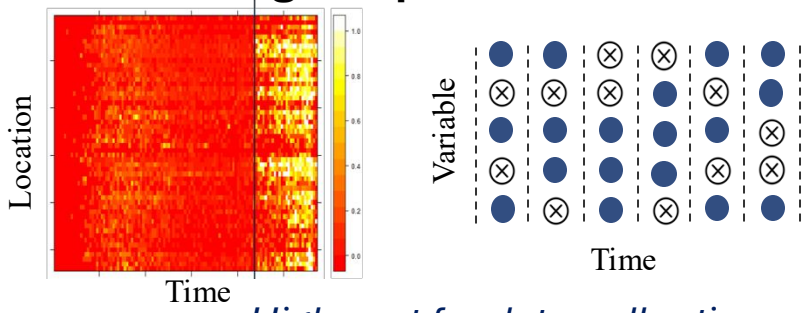
Zan X., Semenov A., Wang C., Xian X., and Geremew W. (2024), "Causality-aware Social Recommender System with Network Homophily Informed Multi-Treatment Confounders", *Information Sciences, 676*, 120729.

Contact: xin-zan@uiowa.edu

Topic II: Adaptive sampling and resource allocation for quick change detection

Challenges: Incomplete or insufficient data due to practical resource constraints in data collection

Online nonparametric monitoring in **manufacturing** and **public health** surveillance

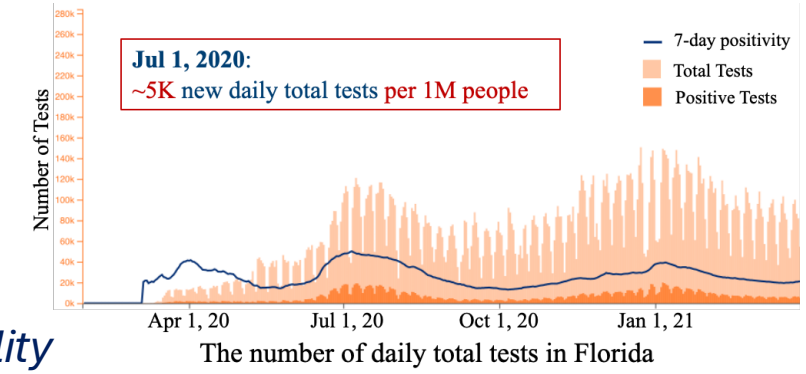


High cost for data collection, transmission, and processing

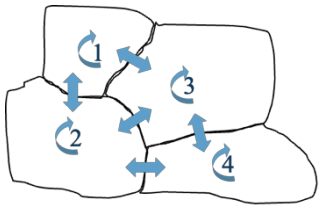
- ✓ Actively and adaptively determines which variables to observe
- ✓ Enables quick detection of unknown abnormalities once they occur in the system

Early detection of **infectious disease** outbreaks

Limited testing availability



- ✓ Integrates physical information for infection transmission modeling and health risk assessment
- ✓ Intelligently allocates limited diagnostic tests among different communities



Illustrative example of disease transmission

Zan X., Wang D., & Xian X. (2023), "Spatial Rank-Based Augmentation for Nonparametric Online Monitoring and Adaptive Sampling of Big Data Streams", *Technometrics*, 65(2), 243-256.

Zan X., Hall J., Hladish T., and Xian X. (2024), "Data-driven Adaptive Testing Resource Allocation Strategies for Real-time Monitoring of Infectious Diseases", *IISE Transactions, 56*(12), 1279-1293 .

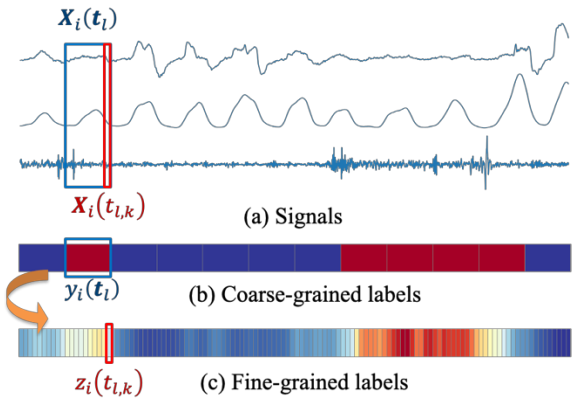
IOWA Department of Industrial and Systems Engineering

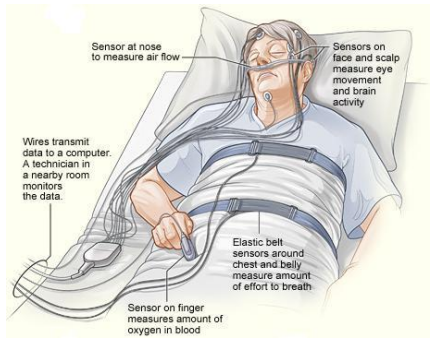
Contact: xin-zan@uiowa.edu

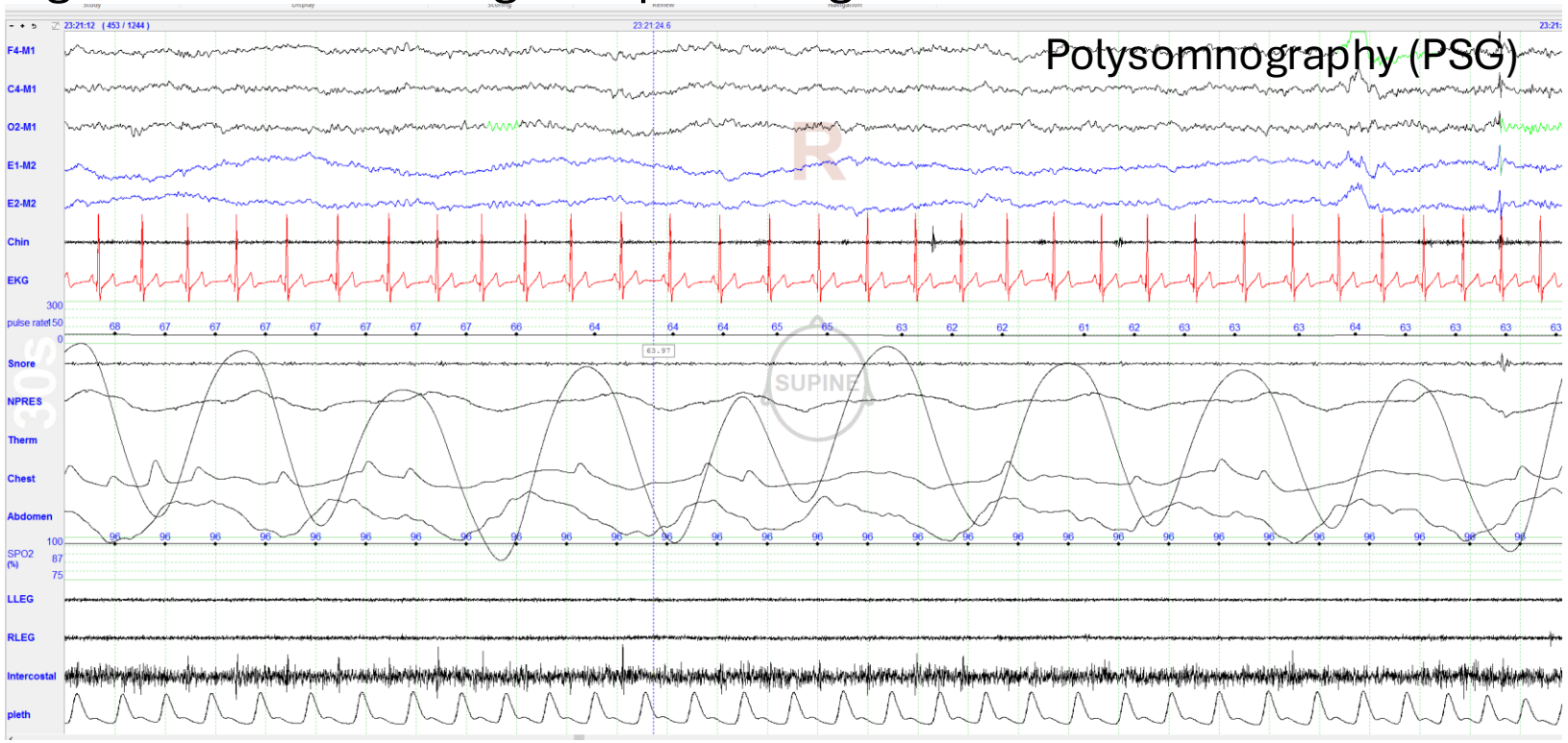
Topic III: AI and data science in sleep disorders

Challenges: Limited well-annotated data due to high manual labeling costs

- ✓ Develops weakly supervised learning for assessing detailed apnea severity directly from multi-channel physiological signals using only inexpensive, coarse-grained labels
- ✓ Mathematical encoding of clinical knowledge of apnea diagnosis







Zan X., Wang D., Song C., Liu F., Xian X., & Berry R. (2025), "Weakly Supervised Deep Learning for Monitoring Sleep Apnea Severity Using Coarse-grained Labels", *IEEE Transactions on Automation Science and Engineering*, accepted.

Contact: xin-zan@uiowa.edu