EE-626

Graph representations for biology and medicine

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Cursus	Sem.	Type
Electrical Engineering		Opt.

Language of teaching	English
Credits	2
Session	
Exam	Oral
Workload	60h
Hours	**28**
Lecture	28
Number of positions	**48**

Frequency

Every year

Remark

Next time: Fall 2024

Summary

Systems of interacting entities, modeled as graphs, are pervasive in biology and medicine. The class will cover advanced topics in signal processing and machine learning on graphs and networks, and will showcase applications of the tools in biomedicine.

Content

Summary

Students will learn how to capture complex interactions in biology and medicine through networks, and how such a general data representation framework can lead to novel discoveries. The class will cover advanced topics in signal processing and machine learning on graphs and networks and will showcase applications of the tools in biomedicine. This course will be held as an advanced seminar, which will familiarize students with recent developments in the topic, through a combination of lectures on some fundamentals on processing and analyzing data on graphs, and the presentation of original research articles that make use of these tools for scientific advances in biology and medicine. Students will learn to interact with scientific work, analyze and understand strengths and weaknesses of scientific arguments, summarize essential ideas, and develop them further in their research. Besides obtaining a good understanding of graph AI tools for biomedicine, the students will improve their presentation and communications skills.

Syllabus

- Introduction into network medicine, graph processing and representation learning for biology and medicine
- General introduction to recent developments in graph theory, graph machine learning, graph signal processing, graph generative models
- Presentation of research articles in the following topics:
- Graphs for disease understanding (e.g., spatial biology, neuroscience)
- Graph generative models for medicine (e.g., therapeutic developments, synthetic data generation through diffusion models)
- Graphs for computational efficiency (e.g., 3D modeling of arteries, computational fluid dynamics)
- Graphs for multimodal data integration (e.g., knowledge graphs for knowledge discovery, design of novel clinical trials)

Structure

The basics of graphs and graph machine learning will be covered by the instructor in the first weeks of the course. After that, students will be expected to read, review, present, and discuss relevant research papers in one of the above-mentioned topics. Every week, one or more students will be responsible for reading one or more research papers, and prepare a presentation highlighting and discussing the important points. All students will be responsible for reading the paper, and contributing to the discussion of the papers' merits and weaknesses. The precise papers will be specified in the first two weeks of the semester, after taking into account the background and interests of the participants.

Keywords

Graph representation learning, machine learning, network science, biology, medicine.

Learning Prerequisites

Required courses

Good knowledge of machine learning; strong interest in biology and medicine; basics of graph theory, graph signal processing and graph machine learning are desirable but not necessary; Python.

Learning Outcomes

By the end of the course, the student must be able to:

- Explore recent developments in graph machine learning for biology and medicine
- Brainstorm on future developments of these tools in other medical or biological applications
- Apply graph machine learning and signal processing tools to their own biomedical research
- Analyze and summarize scientific work
- Synthesize arguments into scientific presentations

Assessment methods

Oral exam.

Resources

Bibliography

- Li, M., Huang, K., and Zitnik, M., Graph representation learning in biomedicine and healthcare, Nature Biomedical Engineering, 6, 1353-1369, 2022.
- BarabÃ¡si, A.-L. Network medicine â## from obesity to the â##diseasomeâ##. N. Engl. J. Med. 357, 404â##407 (2007)

Ressources en bibliothèque

- Barabási, A.-L. Network medicine - from obesity to the "diseasome". N. Engl. J. Med. 357, 404-407 (2007)
- Li, M., Huang, K., and Zitnik, M., Graph representation learning in biomedicine and healthcare, Nature Biomedical Engineering, 6, 1353-1369, 2022

Moodle Link

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