AidroLab “MSc Thesis” openings at EEMCS

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Contact

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We have several projects for learning over graphs including both theoretical and practical approaches. A non-exhaustive list comprises:

- **Graph Neural Networks**: new architectures; theoretical analysis; experimental validation for recommender systems and biological networks (protein-to-protein interactions, epilepsy); prediction of time-varying signals over networks such as temperature evolution; distributed learning.
- **Graph Signal Processing**: regularization on graphs; sampling graph data; active learning, applications to distributed signal processing, sensor networks, and biological networks (protein-to-protein interactions, epilepsy); graph anomaly detection.
- **Graph-based recommender systems**: new algorithms using graph neural networks and random walks; theoretical analysis; experimental evaluation; graph collaborative filters; diversity-enhanced methods; privacy-preserving recommendations, predicting recommendations over time.

Note. I am looking for self-motivated and ambitious students with a strong deadline-oriented profile and the desire to make an impactful thesis. Depending on the findings and results, you should be willing to write an academic article for top venues. If you have this desire, I will help you reach this goal. If you would like to do a thesis under my supervision send me the following information by email: i) exams taken including those of the bachelor; ii) curriculum; iii) topic of interest; iv) preferred start and end date. The above are very broad highlights. To have a better idea give a look to what current and past students did, send me an email or pass by to have a chat. You can also give a look to the examples in the following pages

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MSc Thesis Project

Geometric Deep Learning for Urban Water Networks

Open

Overview

Urban water systems are facing growing pressure from climate change and increasing demographics, forcing cities to devise new approaches to ensure water supply, sanitation and flood risk management. The progressive digitisation of the water sector allows artificial intelligence to play an important role in meeting these challenges towards a sustainable future. While conventional machine and deep learning techniques are showing promise, they ignore the structure of the urban network infrastructure. Geometric Deep Learning (GDL) can effectively take the complex interrelationships of water networks and urban systems into account, allowing the development of ground-breaking data-driven solutions. This master project are related to one of the core research directions in *AidroLab*.

Assignment

In this project, you will focus on building GDL tools for situations where the (urban) water networks fail, for instance due to blocked pipes or a burst/leak. You will consider state-of-the-art solutions and build a robust learning framework that can account for these issues during learning. You will study the different tradeoffs imposed by robust learning and develop methods for improving them. You will work with time series data therefore you will work with GDL solutions that capture together the network structure and the data relationships over time.

Supervision: high together with Dr Riccardo Taormina; Publication possibilities: high.

Requirements

A master student with a strong background in data science and deep learning. You should know and have implemented Recurrent Neural Networks and have basic knowledge of network theory or network data science . Advanced coding skills in one computer language, including Matlab, Python (preferred), or R is a must. Knowledge about GDL or water networks is not necessary as you will learn the relevant background during your thesis project

MSc Thesis Project

Deep Learning over Networks

Open

Overview

Nowadays we have data generated by networks in all social platforms, brain measurements, molecule interactions, sensor networks, and recommender systems to name just a few. This massive amount of data carries hidden information that can help us identify fake news, discover new drugs, identify malfunctioning sensors, and make useful recommendations. All the above applications require new learning tools to extract information and identify meaningful embeddings.

Inspired by the success of deep learning methods in speech and images, we want to adopt similar techniques for learning from network data. Graph neural networks (GNNs) extend the deep learning paradigm to the network setting and allow capturing the information with a similar layered structure. There are still several open directions within GNNs such as identifying the right architecture or adapting current ones to the task at hand.

Assignment

In this master project, you will be hands on GNNs for using them in any of the above applications. You will develop new architectures that better capture the graph structure and also investigate which network characteristics are more meaningful for the task at hand. You will also investigate scalable methods to handle large-scale networks in an efficient manner.

Supervision: high; Publication possibilities: high.

Requirements

You should have a strong machine learning, network theory and deep learning background. You will focus mainly on practical and implementation aspects of the problem. Advanced coding skills in Python and Pytorch/Tensorflow are a must.

MSc Thesis Project

Forecasting Time Varying Signals on Networks

Open

Overview

Forecasting time varying signals on networks is of crucial importance in weather sensor networks, finance, and biological networks. Therefore, modeling and analyzing the effects of time varying network signals is a topic of high importance. We can represent sensors as nodes of a graph and communications links as edges. The temperature measured in each sensor is a signal residing on the nodes on this graph, where the signal temporal evolution is dictated by the underlying topology. However, the effects of a temperature change in adjacent nodes are difficult to model with conventional techniques. Recent techniques from graph signal processing and network theory can be an effective way to time varying signals on networks. These models exploit the network structure and harmonic analysis of the node signals based on the graph Laplacian eigendecomposition. Subsequently, graph filtering techniques can be used to model the signal changes and capture the influence of the underlying topology in the process dynamic.

Assignment

In this master project, your task is to model the time varying signals through graph filters. Two important questions to answer are: i) How to build an effective graph structure for modeling the underlying network? ii) How to exploit this network and graph filters to model the signal temporal evolution? You will work on both theoretical and practical aspects of the project and will compare your algorithm with different baselines models.

Supervision: high; Publication possibilities: high.

Requirements

This project requires a student with a strong theoretical background in network science or signal processing. Knowledge of optimization techniques and network dynamics may result in handy. You also need to have coding skills in one computer language including, including Matlab, Python (preferred), or R.