LINKÖPINGS UNIVERSITET

Preliminary syllabus (v260107)

Course Title: Transfer Learning for life science

Number of credits: 5 ECTS

Course leader: Oleg Sysoev

Department of Course leader: Division of Statistics and Machine Learning, Department of Computer and information Science

University of Course leader: Linköping University

Course Description

Transfer learning is a branch of machine learning that enables transferring information from one knowledge domain into another related domain. This methodology is particularly valuable in the data driven life science, for example in medical imaging and transcriptomics, where labelled data can be scarce and/or expensive to obtain. At the same time, there are many publicly available repositories containing valuable information that can be transferred into related biomedical contexts. Transfer learning makes it possible to transfer information across cell populations, instruments, medical institutions and different data types and allows for greatly reducing the resources needed to develop accurate predictive models. The course will explore different transfer learning paradigms and models at a conceptual level, will introduce the relevant software tools, and will study use cases from domains such as medical imaging, omics, and clinical data.

Intended learning outcomes

- Understand the fundamentals and taxonomy of transfer learning.
- Account for the main models and tools from the transductive, inductive and unsupervised learning
- Select appropriate transfer learning method for a given life science problem
- Use relevant software to perform a given transfer learning task
- Evaluate performance of the transfer learning results

Course contents

- Introduction to transfer learning and challenges in life science data. Taxonomy of transfer learning. Software for transfer learning.
- Architectures for transfer learning: feed-forward networks, convolutional networks, adversarial networks, autoencoders, transformers, contrastive deep learning
- Transfer learning problems: inductive, transductive (domain adaptation), unsupervised and negative transfer learning
- Transfer learning algorithms: Instance-based, feature-based, parameter-based and relation-based
- Transfer learning in data-driven life science: use cases including medical imaging, electronic health records, pharmacology, genomics, proteomics, metabolomics.

- Final project: application of transfer learning for a life science application.

Tentative course overview:

Day	Mode	Activities
1	Online	• 9.30-12.00 **Lecture:** *Overview of architectures for transfer learning: feed-forward networks, convolutional networks, adversarial networks, autoencoders, transformers, contrastive deep learning*
2	Campus	• *9.30*-12.00 **Lecture**: *Introduction to transfer learning and challenges in life science data. Taxonomy of transfer learning. Software for transfer learning.* • *13.30-16.00* **Practical session**: Software for transfer learning
3	Campus	• 9.30-12.00 **Lecture**: *Inductive transfer learning.* Use cases, such as: o Tumor classification from medical image data with pretrained architectures o Clinical text classification by transfer learning from large text corpora o Prediction of pharmacokinetic parameters of drugs by transfer learning from small molecules o Cell type classification of single cell data by transfer learning from other single cell data o Protein function prediction by transfer learning from protein sequences o Tumor classification by transfer learning from self-supervised natural image models • 13.30-16.00 Practical session: inductive transfer learning
4	Campus	• 9.30-12.00 **Lecture**: *Transductive transfer learning.* Use cases, such as: o Cross-species prediction with domain adaptation o Disease classification with adversarial transfer learning o Transferring drug response predictions between conditions o Representation transfer between metabolic datasets • 13.30-16.00 **Practical session**: transductive transfer learning
5	Campus	• 9.30-12.00 **Lecture**: *unsupervised transfer learning. Homogeneous and heterogeneous transfer learning*. Use cases, such as: o Tissue histology classification o Co-clustering of multimodal single cell data o Unsupervised prediction of mutational effects of homologous proteins o Knowledge transfer between natural images and hyperspectral medical images • 13.30-16.00 **Practical session**: unsupervised, homogeneous and heterogeneous transfer learning
6	Campus	• 9.30-12.00 **Lecture**: *Negative, zero-shot and few-shot transfer learning*. Use cases, such as: o One shot medical image segmentation o Zero-shot protein function prediction o Zero shot-learning with GPT and clinical records o Negative transfer in medical images o Negative transfer in drug response prediction • 13.30-16.00 **Practical session**: negative, zero-shot and few-shot transfer learning
7*	Online	9.00-16.00 **Project presentation and opposition** group 1
8*	Online	9.00-16.00 **Project presentation and opposition** group 2

*Days 7-8 will be arranged few weeks later than Day 6 to allow students for completing the project work.

Course activities

Course include lectures, laboratory tasks and project work, as well as presentations of the project work and opposition of some other student's project presentation.

Specific requirements

- Completed course in "Deep Neural Networks in Life Science Applications"
- Programming experience in Python, R or Matlab

Literature

- Various scientific papers
- Book "Transfer learning" by Yang et al. https://books.google.se/books/about/Transfer_Learning.html?id=CLyDxgEACAAJ&redir_esc=y