Deep Learning for Physics and Astronomy

University of Victoria - PHYS 555

Pre-requisites

Math

- linear algebra, optimization, probability, statistics

Computing

- knowledge of python and scientific libraries (numpy, scipy, pandas, ….)
- familiarity with jupyter notebooks

Deep Learning Module

- Practical approach with pointers for "going further"
- Lessons will consist of slides and practical notebooks
- Students are strongly encouraged to go through the material before

Grading:

- Two short homeworks.
- One paper presentation.
- One project

Deep Learning Module Program

Feb 28	Introduction to Neural Networks - Automatic Differentiation
March 02	Shallow and Deep Learning- Convolutional Neural Networks
March 07	Optimization, back-propagation, Training, Overfitting
March 09	Equivariance & Inductive Biases. Model evaluation.
March 14	Sequential data: recurrent neural networks, attention.
March 16	Deep Learning Architectures 1: CNN, Autoencoders, UNet
March 21	Deep Learning Architectures 2: Transformers, Masking, conditioning
March 23	Deep Generative Modelling 1: GANs, VAEs
March 28	Deep Generative Modelling 2: Normalizing flows, diffusion models
March 30	Paper Presentations
April 04	Uncertainty quantification with deep learning, simulation-based inference
April 06	Sets & Graphs with Neural Networks.
April 11+	Project Presentations

Deep Learning Module Grading

Homeworks	10
Paper Presentation	10
Project	30
Total	50

Paper Presentation

- Read, Summarize and Present a paper
- Can be any of machine learning, statistical learning, machine learning with physics, application of ML within a physics or astronomy
- Recommendations:
    - For papers on application of ML in science: focus on the method and what ML brings.
    - Have a critical discussion of the paper.
    - Share the paper link with instructor at the latest of 1 week before presentation
    - Discuss with instructor if you need suggestions.

Constraints:

- You can work in groups of maximum 2 students - Presentation should be split evenly
- 8min+2min questions (will depend on the class size).

Project

- Project topic at student discretion
  - Can be an Machine Learning paper, an application of ML in any topic of physics, or hybrid ML+Physics…
  - Can be related to student research topic
- Share a 1-page-max abstract and roadmap of the plan with instructor
- Max of 2 students per project
- Project report is a jupyter notebook containing descriptions and working code
- Project presentation 10min + 2min questions
- Report and presentation need to show clear contributions of each student
- If you need special accommodation, please let us know!

Software environment

- All course material will be possible on Google Colab
- Projects requiring large datasets or larger compute, let us know.
- Course and notebooks will be demonstrated with PyTorch.
- No restrictions on the software for the project