Lecture Series

on

Mathematics of Deep Learning with an Emphasis on Inverse Problems

by

Ozan Öktem (lectures 1-3)
KTH, Stockholm

and

Jonas Adler (lectures 4-5)
KTH, Stockholm

Dates:
Wed, 11.04.2018; 13:00-14:00 p.m.; **IMS** SR 5.101
Wed, 18.04.2018; 13:00-14:00 p.m.; **NAM** MN67 (lecture hall, ground floor)
Thu, 19.04.2018; 13:00-14:00 p.m.; **IMS** SR 5.101
Tue, 24.04.2018; 13:00-18:00 p.m.; **NAM** terminal room (ground floor, room 6)
Wed, 25.04.2018; 13:00-18:00 p.m.; **NAM** terminal room (ground floor, room 6)

Places:
IMS, Goldschmidtstr. 7, 37077 Göttingen
NAM, Lotzestr. 16-18, 37083 Göttingen

Registration:
Please register via email to Diana Sieber (dsieber@gwdg.de), indicating if you plan to attend only parts 1-3 or also parts 4 and 5!

Abstract:
Deep learning has had stunning practical success in addressing a wide range of tasks, especially related to signal processing and playing games. The course will provide a brief overview of current attempts at developing a mathematical theory for deep learning with an emphasis on its recent usage for solving inverse problems. It consists of five lectures among which the first three are devoted to theory and the last two are devoted to computational aspects. Note that there are relatively few results that are practically useful and have been proved mathematically. In contrast, the number of examples and open problems is more abundant.

Course description:

Lecture 1: Introduction to machine learning and some of its underlying mathematics
Date & time: April 11, 13:00-14:00
Location: IMS-SR 5.101
Content
This aim is to introduce basic notions from machine learning. We will quickly focus on supervised learning in the purely data driven setting, i.e., there are no physics driven mechanistic models for how training data is generated. The aim is to survey some of the results and open problems associated with developing a mathematical and computational theory for deep learning in this setting.

Lecture 2: Machine learning in the context of inverse problems: Learning priors and post-processing
Date & time: April 18, 13:00-14:00
Location: NAM, MN67 (grosser Hörsaal)
Content
Focus here is on applying machine learning to solve an ill-posed inverse problems, i.e., to recover an operator that maps the data to signal. The starting point is to very briefly survey current regularisation schemes emphasising on the ability to account for a priori information. Next, is to outline challenges associated with using machine learning for solving ill-posed inverse problems followed by a survey on early attempts that are based on using it as a post-processing step. We conclude with outlining the limitations with this latter approach.

Lecture 3: Learned iterative schemes
Date & time: April 19, 13:00-14:00
Location: IMS-SR 5.101
Content
This lecture introduces specific deep neural networks for solving ill-posed inverse problems that account for the a priori information contained in a forward model. We outline the current approaches, point to open problems, and conclude with showing examples of their performance illustrated in tomographic image reconstruction,

Lecture 4: Computational approaches for learned iterative schemes I
Date & time: April 24, 13:00-18:00
Location: NAM, Terminalraum
Content
This lecture starts out by introducing the software package Operator Discretization Library (ODL) available from https://github.com/odlgroup/odl. The aim is to illustrate how many state-of-the-art iterative/variational regularization methods can be used from within ODL. Examples and accompanying excersizes are on tomographic reconstruction and our goal is on getting you started with ODL for your own inverse problem (which may not necessarily involve tomography). Depending on time, we may also start introducing how learned iterative schemes are implemented.

Lecture 5 + Exercises: Computational approaches for learned iterative schemes II
Date & time: April 25, 13:00-18:00
Location: NAM, Terminalraum
Content
This lecture with accompanying excersizes aims to introduce how learned iterative schemes are implemented using ODL and Tensorflow.

Remark
Lectures 4 and 5 include lab-sessions and target usage of ODL and deep learning for solving large scale inverse problems from tomography. For this reason, attendants must have access to computers where ODL and the required packages (ASTRA for tomography and TensorFlow for deep learning) are already installed. Most of the material is doable without a GPU acceleration, but the performance will be sub-optimal. Hence, it is highly preferable if attendants have access to GPU accelerated computers. In conclusion there are two options:

(1) Attendants bring with them a GPU accelerated laptop or remote desktop capability to a computer with a NVidia GPU where they have already installed ODL and the required packages (ASTRA for tomography and TensorFlow for deep learning). Due to the nature of the course, we will assume that the latest versions are installed (ODL master branch and tensorflow ≥ 1.3). Please see the installation instructions (https://github.com/odlgroup/odlworkshop/blob/master/code/part0_install.ipynb).

(2) Attendants are given temporary access, via remote desktop, to the computational environment at KTH, Stockholm where an computational environment containing the necessary components is available.

Attendants that consider option (2) should get in contact with Jonas Adler <jonasadl@kth.se> to ensure access to the computational environment at KTH, Stockholm.