Workshop at the Centre of Interdisciplinary Mathematics (CIM): "Deep Neural Networks for Beginners"

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Title: "Deep Neural Networks for Beginners"

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Dates: October 14-16, 2019

Location: Uppsala University, lecture hall TBA

Target Audience: Master's students, doctoral students, postdocs and faculty of the Uppsala University. Overall, the course is addressed to all students and researchers who are interested in applied machine learning (ML), Artificial Intelligence (AI) and interdisciplinary research, who would like to familiarize themselves with the basic ML/AI concepts and methods, and who want to keep themselves updated about recent developments. At the Uppsala University, we expect to recruit course participants not only from the Disciplinary Domain Mathematics and Computer Science, but also participants from the Departments of Biology and Earth Sciences, Chemistry and Faculty of Medicine will surely find it fruitful to attend the course and discuss the methods and applications of ML and AI which are becoming increasingly common in their research areas, and to apply the newly gained knowledge in practical sessions.

Maximum number of participants: 25

Minimal requirements:

- Basic programming skills (experience in Python is helpful, for the practical exercises we will organize the students in 2-3 person groups to optimize the programming experience)

- Basic knowledge in machine learning, statistics, and mathematics is useful

Motivation:

The need for methods to automatically, objectively, and efficiently analyze and interpret data is a common task in many scientific areas. Machine learning is an essential part of this task, where especially deep learning plays a central role. Advances in the field of deep learning have led to a development in machine learning methods such as deep neural networks, which outperform classical methods in many fields. One of the main reasons of their success is the ability to uncover hidden and complex structures in the data, where layered architectures are employed to extract a deep and rich hierarchical feature representation, which is particularly suitable for solving certain tasks.

Several applied scientific communities such as the remote sensing community started to use deep learning approaches for their application tasks including the identification of objects and forecasting of bio- and geophysical parameters. This illustrates an increasing demand for interdisciplinary approaches that bridge the gap between machine learning and disciplines such as natural sciences.

The global scope of this course is to lay the foundations in machine learning and provide necessary deep learning tools in the context of applied sciences. In detail, it includes **lectures** about fundamental and advanced concepts in neural networks and deep learning, which will be presented with allocated time for discussions. The gained knowledge will be applied in three **hands-on sessions** covering various practical aspects. The sessions will cover all necessary aspects of machine learning pipelines that work on real world applications, covering data pre-processing, model learning and testing, as well as quantitative and qualitative evaluation.

The proposed course builds upon a similar course offered at the GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany, in February 2019 which was very well received.

Objectives:

- Understanding the basics in classification and regression
- Understanding the basics in neural networks
- Application of neural networks in hands-on sessions (Python programming sessions)
- Usage of Keras and Tensorflow to train and build deep learning models for applied sciences
- Analysis and evaluation of results obtained in hands-one sessions
- Participation in interactive discussion
- Presentation of results
- A course evaluation will be carried out during the week following the course to collect the feedback

Covered topics:

- Basics in machine learning: classification + regression (learning, testing, evaluation)
- Challenges in machine learning
- Classification paradigms and classification tasks
- Representation learning
- Basics in neural networks and deep learning
- Backpropagation
- Cross-validation
- Convolutional neural networks, recurrent neural networks, Long-short-term memory networks

Computational setup:

We will apply for computational time and storage to the educational programme of the Swedish National Infrastructure for Computing (SNIC).

Time schedule:

Day 1

- 4 x 45 min: lecture ‘Introduction to neural networks’
- 3 x 45 min: hands-on ‘Neural network regression’

Day 2

- 4 x 45 min: lecture ‘Deep neural networks for applied sciences’
- 3 x 45 min: hands-on ‘Time-series forecasting’

Day 3

- 2 x 45 min: hands-on ‘Object identification’
- 3 x 45 min: time for individual discussions of the exercises with course participants