Training

Machine Learning for Image Analysis

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Date: Monday 29 - Wednesday 31 October 2018

Venue: EMBL - EMBL- Heidelberg, Meyerhofstraße, 69117, Heidelberg, Germany

Application opens: Monday May 07 2018

Application deadline: Friday June 15 2018

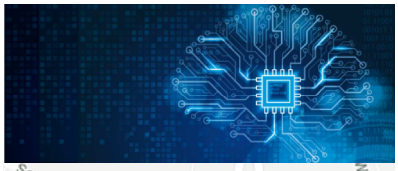
Participation: Open application with selection

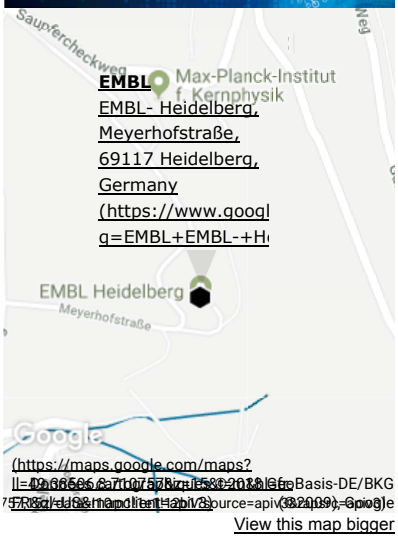
Contact: Charlotte Pearton (mailto:cpearton@ebi.ac.uk)

Registration fee: £0

Apply now » (https://embl.ungerboeck.com/prod/emc00/register.aspx?OrgCode=20&EvtID=5624&AppCode=REG&CC=118050430823)

Dates additional information: Up-front online sessions: 2nd, 9th and 16th October 2018 (12:00-14:00 CEST) On-site workshop: 29-31st October 2018 Follow-up online sessions (optional): 9th and 16th November 2018





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Course Overview

This is a blended learning course on Machine Learning for Image Analysis, consisting of three online sessions with associated hands-on exercises prior to the workshop, a three day face-to-face workshop at EMBL Heidelberg and two optional online sessions with associated hands-on exercises after the workshop. The course is jointly organised by CORBEL, EMBL, German BioImaging and NEUBIAS (COST Action CA15124).

The course will be a great mix of intensive learning, extensive hands-on and community networking in the field of Machine Learning for Image Analysis.

- **Up-front online sessions:** Participants will review the fundamentals of machine learning in three up-front webinars complemented by online tutorials. The webinars will take place on 2nd, 9th and 16th October 2018, 12:00 - 14:00 but a recorded alternative can be provided.
- **On-site workshop:** Next, they will apply their knowledge at an on-site workshop (EMBL Heidelberg, October 29-31), in small interactive groups (the workshop has 20 available seats and ~8 trainer/lecturer), to both reference datasets and their own data. Topics to be practiced in these groups include: 2D and 3D segmentation with convolutional neural networks, Content aware image restoration, simulation of ground truth data, labeling strategies and transfer learning. Participants will be asked to pick one group for the practical sessions.
- **Follow-up online sessions (optional):** After the on-site workshop, two optional advanced training webinar, complemented by a online tutorials, will be given on 9th and 16th November 2018. These will focus simulation of data, transfer learning and boosting.

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EMBL

Practical Sessions (participants will be asked to choose one during registration):

Detection and Segmentation in microscopic images (Thorsten Falk):

- Topics: Segmentation with convolutional neural networks, Pattern in bio-medical image data
- Typical data: Results of multi-labeling high content screens
- Tools: Python, Keras, Tensorflow

Segmentation in 3D microscopy image stacks (Anna Kreshuk & Constantin Pape):

- Topics: 3D segmentation (with convolutional neural networks), 2D, 2.5D and 3D networks and their combinations, Pre- and post-processing tricks, Combination of deep and “shallow” learning
- Typical data: 3D datasets recorded by light or electron microscopy
- Tools: Python, Keras, PyTorch

Transfer learning and how to use synthetic data for supervised deep learning (David Rousseau & Pejman Rasti):

- Topic: Basics of transfer learning
- Typical data: PALM/STORM, 3D cells in spheroid imaged in light sheet fluorescence microscopy and 3D plant roots images in absorption X-ray tomography
- Tools: Python, Keras, Tensorflow

Content-aware image restoration (Martin Weigert):

- Topics: Content aware image restoration, Simulation of images for light microscopy
- Typical data: Pairs of light microscopic images imaged in ideal and suboptimal conditions
- Tools: Python, Keras, Tensorflow

Audience

This course is aimed at both core facility staff and research scientists.

Prerequisites for this workshop are programming skills in Python and ideally Tensorflow, Keras or Pytorch as well as basic knowledge of machine learning theory.

Participants should provide an outline of one image analysis task that holds potential to be ideally solved with machine learning. Neural networks have been successfully applied to various medical and biological imaging modalities including PALM/STORM, light sheet fluorescence microscopy, high-throughput microscopy, electron microscopy, X-ray tomography. However, they require observation-outcome-pairs for training. Ideally, you will provide annotated images.

Learning outcomes

After this course you should be able to:

- Explain the fundamentals of machine learning methods suitable for image analysis

How to apply

In order to be considered for a place on this course, the application process is as follows:

1. Complete the online application form
2. Submit a WORD document to cpearton@ebi.ac.uk (mailto:cpearton@ebi.ac.uk) containing the following information (by 15th June 2018):

- Please explain your theoretical background and practical experience in programming and machine learning. If applicable, please provide the links/references to the repositories of open source projects, abstracts and/or challenge results (100 words).
- Please describe your motivation to attend the course. If you have a defined question to be solved in the practical sessions, please explain it. Please describe how this course will benefit your research and the work of your group/department/institute.

Further details will be provided on your confirmation email after completing the online form.

Incomplete applications will NOT be considered.

NEUBIAS (COST Action CA15124) is providing up to 4 travel grants upon selection (paid after the event, amount based on justification of expenses). Please send your travel grant application (application documents + justification for the travel grant in 4-5 sentences) as a single PDF to: Julien Colombelli julien.colombelli@irbbarcelona.org (mailto:julien.colombelli@irbbarcelona.org)

- Consult users/colleagues in strategies to obtain ground truth
- Give advice in training and using a neural-network
- Perform simple quality control on the results of one selected ML approach

Programme

The programme is subject to minor changes

Time	Topic	Trainer
Day 1 - Monday 29 October 2018		
09:00 - 09:15	Registration	
09:15 - 09:30	Welcome and Course introduction	Tobias Rasse, Anna Kreshuk
09:30 - 11:00	Flash talks by participants	
11:00 - 11:15	Tea and Coffee break	
11:15 - 12:45	Overview group projects	All instructors
12:45 - 13:30	Lunch	
13:30 - 15:30	Practical (sample data)	in project groups
15:30 - 15:45	Tea and Coffee break	
15:45 - 18:00	Practical (own data)	in project groups
18:00 - 18:45	Keynote	Fred Hamprecht
19:00 - 19:45	Dinner	
19:45 - 20:45	Introduction to Tensorboard	Anna Kreshuk
Day 2 - Tuesday 30 October 2018		
09:00 - 10:00	Common Pit faults in using CNN	Anna Kreshuk, Thorsten Falk
10:00 - 11:00	Check & analyze results	Project groups
11:00 - 11:15	Tea and Coffee break	
11:15 - 12:00	Practical (own data)	Project groups
12:00 - 12:30	Progress and issues	All
12:30 - 13:15	Lunch	
13:15 - 15:00	Practical (own data)	Project groups
15:00 - 15:15	Tea and Coffee break	
15:15 - 16:30	Practical (own data) and prepare presentation	Project groups
16:30 - 17:30	Presentation of completed projects	All

before registration closes. It is important that you demonstrate why you need a travel grant in order for us to fully assess your request. The grants are supported by COST (funding body of the NEUBIAS Action). Eligibility and reimbursement modalities will follow the criteria/general COST policies. Decision on travel grants will be communicated by 15th July.

Application deadline

15 June 2018

Number of places

16 places

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Organisers

Anna Kreshuk - EMBL

Vera Matser

Tobias Rasse - EMBL

Trainers

Thorsten Falk - Freiburg University

Fred Hamprecht - Heidelberg University

Anna Kreshuk - EMBL

Constantin Pape - Heidelberg University

Tobias Rasse - EMBL

Pejman Rasti - Université d'Angers

David Rousseau - Université d'Angers

Martin Weigert - MPI-CBG

Materials & attachments

Course Poster (ftp://ftp.ebi.ac.uk/pub/training/publications/

Add to calendar

17:30	Social event	
Day 3 - Wednesday 31 October 2018		
09:00 - 09:30	Blended workflows	Anna Kreshuk
09:30 - 10:00	Simulation of data	David Rousseau, Martin Weigert
10:00 - 10:30	Fine tuning and domain transfer	David Rousseau, Pejman Rasti
10:30 - 10:45	Tea and Coffee break	
10:45 - 12:45	Practical	Project groups
12:45 - 13:30	Lunch	
13:30 - 15:30	Project presentations	All
15:30 - 16:15	Wrap up and feedback	
16:15	End of course	

Additional information:

Full details for the practical sessions (participants choose to join one group):

Detection and Segmentation in microscopic images (Thorsten Falk, University of Freiburg)

Neural Networks are extremely powerful in learning various image processing tasks. Their biggest strength is their easy adaptability to very different applications by simply training them with application-specific corresponding observation-outcome pairs. Especially in biology where imaging is by no means standardized and the number of applications on various scales is uncountable, neural networks can be the swiss army knife for image analysis. However, the required observation-outcome-pairs for training are also their biggest weakness. The key for good models is a sufficient amount of high quality training data covering the distribution of possible observations.

The focus of this workshop will be instance detection and segmentation in biomedical image data which can be solved with a comparably simple convolutional-deconvolutional feed-forward network. Image segmentation is one of the most frequently required but also one of the most demanding tasks with respect to training data generation. Each pixel of multiple images must be accurately and consistently annotated to obtain training data for a neural network. You will learn how to properly record, select and annotate images to train a neural network for your task. You will employ data augmentation techniques to reduce the image annotation effort to a moderate level. Finally, the concept of domain adaptation to transfer learnt models from one imaging device to another will be explained in a nutshell.

The workshop will require but also teach manual annotation in Fiji/ImageJ and use a new Deep Learning plugin for simple 2D tasks. 3D tasks can be tackled in a similar fashion but will require python and the caffe framework (this may change to keras/tensorflow depending on preparation time). Attendees need to provide 2D or 3D microscopic data for

structure detection and/or segmentation with corresponding point markers indicating the positions and types of structures to be detected or (potentially multi-class) segmentation masks for training networks for structure segmentation.

Segmentation in 3D microscopy image stacks (Anna Kreshuk and Constantin Pape, EMBL)

We will focus on segmenting 3D data with convolutional neural networks. We'll talk about network architectures that were shown to work well in 2.5D and 3D, about pre-processing and data augmentation, as well as necessary post-processing. We will also introduce and compare tools for groundtruth annotation and proof-reading in 3D.

Transfer learning and how to use synthetic data for supervised deep learning (David Rousseau, Pejman Rasti, Université d'Angers)

"A striking fact when gazing at the first layers of deep neural networks is that these layers almost look like Gabor wavelets. While promoting a universal framework, these machines seem to systematically converge toward tools that humans have been studying for decades. This empirical fact is used by computer scientists in the so-called transfer learning where the first layers of an already trained network are re-used to save time and improve results when limited data sets are available. Another current limitation to the application of deep learning is that this requires huge training data sets to avoid overfitting. Such training data sets have to be annotated when supervised learning is targeted. And, at the moment, the available data sets available among the bioimage analysis community are far from covering the large amount problematics in bioimaging. Here also some possible alternatives exists. This includes the generation of realistic automatic annotated data sets with synthetic simulated images.

During this hands on you will learn the basics of transfer learning with a Jupiter notebook and will learn how to use synthetic data for supervised deep learning. This can be applied to any type of bioimaging problem. A large panel of examples will be given for illustration among which 2D microtubule imaged with PALM/STORM, 3D cells in spheroid imaged in light sheet fluorescence microscopy and 3D plant roots images in absorption X-ray tomography."

Content-aware image restoration (Martin Weigert, MPI CPG)

Fluorescence microscopy of living cells or organisms often results in noisy and axially blurred images, owing to the limited laser power and number of focal planes that are compatible with specimen health or temporal resolution. This is in contrast to acquisitions of fixed specimen, where such constraints are often not present, and where the signal-noise-ratio (SNR) and axial sampling can be chosen almost freely.

In this part of the tutorial, we will explain how machine learning can be used to improve the quality of images that were acquired under adversarial imaging conditions, with the help of adequately acquired high quality images. Participants will learn how to construct image restoration pipelines that are tailored to specific imaging situations and organisms, and will be guided through all the necessary steps: From data pre-processing, model training, and application to new images to the final deployment via Fiji plugins that can be shared with collaborators.

Ideally, the participants should already have a specific experimental situation in mind, where normal imaging conditions would preclude sufficient image quality. To take full advantage of this practical session, they are encouraged to bring already acquired corresponding images/volumes of samples acquired at different (low and high quality) conditions.