Ministry of Human Resources and Social Security

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

2020 Helmholtz – OCPC – Program
for the involvement of postdocs in bilateral collaboration projects

PART A

Title of the project: Deep learning for high-throughput, imaging-based plant phenotyping

Helmholtz Centre and institute:
Forschungszentrum Jülich, Institute of Bio- and Geosciences, Plant Sciences (IBG-2)

Project leader:
Dr. Hanno Scharr

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- Institute: https://www.fz-juelich.de/ibg/ibg-2/EN/Home/home_node.html
- Research Group: https://www.fz-juelich.de/ibg/ibg-2/EN/Research/ResearchGroups/enabling_technologies/Technologies/Image_Processing/Image_Processing_node.html
- Hanno Scharr: https://www.fz-juelich.de/ibg/ibg-2/EN/Staff/Enabling%20Technologies/Scharr_Hanno/Scharr.html?nn=2047902

Description of the project:
Plant phenotyping is the identification of effects on plant structure and function (the phenotype) resulting from genotypic differences (i.e., differences in the genetic code) and the environmental conditions a plant has been exposed to. Knowledge of plant phenotypes is a key ingredient of the knowledge-based bioeconomy, which not only literally helps to feed the world, but is also essential for feed, fibre, and fuel production.

Image processing methods are one of the essential components of high-throughput, imaging-based plant phenotyping. Numerous methods have been developed in the past years that assist the quantitative analysis of plant traits of interest. In this context machine learning approaches and particularly deep convolutional neural networks (DNNs) became more important and show excellent potential in biological sciences, also thanks to increasing computer and graphics card power. Imaging methods are applied in various scenarios at the institute of plant sciences (IBG-2) ranging from the analysis of seeds, whole plants above- and below-ground, as well proximal and remote sensing in the field. Two use-cases will be in focus in the proposed project:

1. IBG-2 operates a Rhizotron facility that allows for non-invasive imaging of roots in soil during the entire plant development. These images are analyzed with respect to different root traits, like total root length, depth and angles, respectively. The application of DNNs will allow for a pixel-wise classification of roots against the heavily cluttered soil background in the image data, which is a prerequisite for further trait analysis.

2. IBG2 has established an imaging-based seed evaluation that can be used for thousands of seeds and different seed types. Available 2D images and 3D-reconstructed seeds allow for advanced analyses based on multiple properties towards seed classification or estimation of 3d traits from 2d images.

The analysis of these image data is still one of the major bottlenecks in data processing. In several cases novel or upgraded phenotyping platforms with increased capacity and throughput require further development of semi- or fully-automated analyses. Image data are readily available, with thousands to hundreds of thousands images each. As not all of this data is fully labelled, we will explore semi-supervised and unsupervised learning methods, e.g. cycle-consistent adversarial networks, as well as transfer learning and domain adaptation.

All tasks of the candidate are focusing closely on plant phenotyping applications. The candidate will

- develop, evaluate and apply semi- and unsupervised deep learning methods in different plant phenotyping applications using the cases indicated above as priorities,
- evaluate to what extent a generic machine learning framework could be re-deployed with minor adaptation to solve different problems in this context,
- investigate how networks pre-trained for a given task can efficiently be adapted to varying imaging conditions not previously seen by the network – e.g. different soil types, plant species and mutants in root segmentation.

Description of existing or sought Chinese collaboration partner institute:
We are looking for a computer science institute focussing on image analysis, computer vision, and/or machine learning. It should be well versed in deep learning from a practical, as well as theoretical angle, as practical requirements often may need the development of novel methodologies rather than plain transferring solutions successfully tested in other domains. As an example, when tracking plants over time, not only their pose changes – like for dancing humans – but they also grow new organs, being tiny at first and becoming larger by orders of magnitude. Plant phenotyping is similar to medical, where humans are measured by imaging devices. However plant phenotyping is much richer in complexity, as it deals with hundreds of different species with thousands of mutants. The sought for institute should therefore have experiences with medical or plant applications, natural sciences or farming. It should have an interest in exploring plant phenotyping, being a field with rich novel challenges, just being picked up by the computer vision community (cmp. the CVPPP workshop series).

Required qualification of the post-doc:
- PhD in Computer Sciences, Mathematics, Physics or a closely related, mathematics- or computing based topic
- Solid experience with Deep Learning in theory and practice, comprising GANs and transfer learning techniques, like Bayesian networks. Practice should include development of new DL methods, rather than only applying well known methods. Experiences in high performance computing and data-parallel training are a plus but no hard requirement. The ideal candidate would also be interested in plant science and plant phenotyping approaches.
- Additional solid skills are required in Python programming and using e.g. Keras/Tensorflow or PyTorch. Technical understanding of Horovod and MPI is a plus.

PART B

Documents to be provided by the post-doc, necessary for an application to OCPC via a postdoc-station in China, which is affiliated to a research institution like a university:

- Detailed description of the interest in joining the project (motivation letter)
- Curriculum vitae, copies of degrees
- List of publications
- 2 letters of recommendation
- Proof of command of English language

PART C

Additional requirements to be fulfilled by the post-doc:

- Max. age of 35 years
- PhD degree not older than 5 years
- Very good command of the English language
- Strong ability to work independently and in a team