UNIVERSITÉ Clermont Auvergne

Subject: Neural Networks for object detection, classification and segmentation applied to 3D bio-imaging

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Abstract:

3D microscopy imaging and image processing (3D bio-imaging) are essential to solve challenges for Life Sciences. The recent progress in Artificial Intelligence are opening up new opportunities never reached before to improve 3D bio-imaging. The proposed PhD project will first implement a current convolutional neural network (CNN) based on U-Net architecture, a fast and precise trainable method for image segmentation and second investigate unsupervised CNN dedicated to the detection and classification of objects here applied to detect regular patterns in plant cells. This multidisciplinary project aims at transferring expertise from computer sciences to biomedical researchers in health and Plant science and between a French and UK University with potential applications in agronomy and human health.

Skills:

Applicants should love interdisciplinary science and have good background in any of computer science or artificial intelligence, with a strong programming ability in a high level language (preferably C/C++, Java or Python). Candidates should hold a Master degree in Computer Science or a related discipline. Prior experience in computer vision or image processing and knowledge of Tensorflow, Keras, Pytorch and/or other deep learning frameworks is a plus although not essential. Applicant should be capable of working collaboratively with researchers from different disciplines and to communicate effectively both orally and in writing at a level in English appropriate to the research and presentation of data.

Keywords:

3D bio-imaging, CNN, health, Plant science, microscopy.

Description:

We are looking for a highly motivated prospective PhD student to undergo a 3-year funded position through a co-agreement between Oxford Brookes and Clermont Auvergne Universities in the area of machine learning and deep learning applications here dedicated to 3D-bioimaging [1]. We propose to build innovative and generic methods based on convolutional neural networks (CNN) such as those developed for U-Net [2], Ilastik [3] or Star dist [4] which have been successfully applied for 3D bio-imaging. This multidisciplinary project between the two partner Universities aims at transferring strong expertise gain by Institut Pascal from computer sciences to biomedical researchers in health and Plant science.

The first task of the PhD project will be to further implement a U-Net CNN currently under development by the GReD team as a new pipeline to segment 3D images. Although large

training datasets have been already generated, curated and used to train the network, a method to define the optimal dataset remained a major hurdle. To this aim, statistical method such as bootstrapping which involves iterative resampling of a dataset will be explored to optimize the size and composition of the training dataset. In a second step, optimized training datasets will be subsequently used to train the CNN. Various sources of 3D images are available from the three partner labs as a starting material for the project including confocal and electron microscopy for plant science and from OCT (Optical Coherence Tomography), advanced radiological technical platform with multimodal imaging coupling (RX+US+IRM) and scanner guidance for Cardio-Vascular Interventional Therapy and Imaging (CaVITI) for human health. With this first part of this project, we intend to set up training methods and robust CNNs well adapted to segment 3D image collections from different sources.
As a second task, the PhD applicant will explore and develop an object classification method also based on CNN to assign identities to relevant features on an image. This will rely on unsupervised CNN strategy and removes the requirement for manual labelling of a training dataset[1]. As a biological challenge, this will be used to define regular pattern in images as chromatin domains, cellular structures like endoplasmic reticulum and nuclear boundaries or cell identity especially in the plant science field.
Finally, the development of the new algorithms will require the industrialization of the prototype algorithms developed during the project by the Artificial Vision team (ComSee) This will ultimately involve designing an application that will include a user interface that is compatible with the expectations of potential users in biology. With this project, we expect that the outstanding potential of CNN will transform the way we acquire and analyze 3D images to an automated high-performance tool well-designed for big-data analysis.

1. von Chamier, L., Laine, R. F. & Henriques, R. (2019) Artificial intelligence for microscopy: what you should know. *Biochem Soc Trans* 47, 1029–1040.
2. Çiçek, Ö et al, (2016) O. 3D U-Net: Learning Dense Volumetric Segmentation from Sparse Annotation. arXiv:1606.06650 [cs].
3. Berg, S. et al. (2019). Ilastik: interactive machine learning for (bio)image analysis. *Nature Methods* 16, 1226–1232.
4. Schmidt, U. et al. (2018). Cell Detection with Star-convex Polygons. *arXiv*:1806.03535 [cs] 11071, 265–273.

Références:

1. Poulet A, Arganda-Carreras I, Legland D, Probst AV, Andrey P, **Tatout C**. (2015) NucleusJ: an ImageJ plugin for quantifying 3D images of interphase nuclei. *Bioinformatics*, 31:1144-6.
2. Bilalovic O.; Avdagic Z.; Omanovic S.; Besic I.; Letic V.; **Tatout C**. (2020) Mathematical Modelling of Ground Truth Image for 3D Microscopic Objects Using Cascade of Convolutional Neural Networks Optimized with Parameters' Combinations Generators. *Symmetry*, *12*, 416.
3. Joubert D., Konik H. et **Chausse F**. (2019) Convolutional Neural Network for Detection and Classification with Event-based Data". In : Proceedings of the 14th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications, p. 200-208, VISIGRAPP 2019, Volume 5 : VISAPP, Prague, Czech Republic, February 25-27.
4. Pain, C., **Kriechbaumer, V.**, Kittelmann, M. et al. (2019) Quantitative analysis of plant ER architecture and dynamics. *Nat Commun* 10, 984.

How to candidate?

Interested candidates are invited to send a motivation letter, a *curriculum vitae* and two reference letters via email before **June 19th** (12:00 CEST) to sophie.desset@uca.fr and frederic.chausse@uca.fr ; Short-listed candidates will be notified by email.