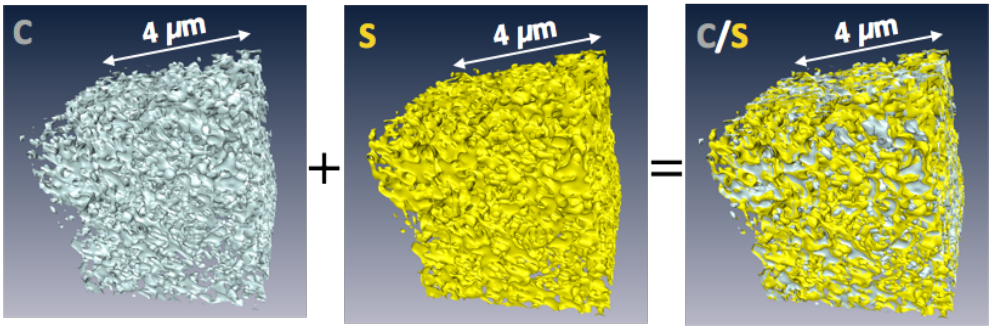
Master Internship in Research
(Materials Science)



Automated Segmentation in X-ray Computed Tomography using Deep Learning

Laboratory: Laboratoire des Réactivité et Chimie des Solides (LRCS)

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Supervisors: Dr. Arnaud Demortière (CR CNRS) et Mr. Zeliang Su (PhD Student)

Required skills: Programming in Python (Numpy, Tomopy, Xlearn), Convolutional Neural Network, FIJI and Avizo softwares.

Contract date: from February 4th to July 31st

Gratification for internship: 550 euros/month

Research topic : X-ray nano Computed Tomography (CT) with a spatial resolution of 20-60 nm is a strong new tool to probe Li-ion battery materials in a non-destructive mode **[1]**. Nano CT allows us to distinguish in 3D different phases of composite electrode such active particle, carbon-binder (CBD) and porosity, which is crucial to properly get insight into electrochemical properties of Li-ion battery. 3D morphological parameters, such as porosity, tortuosity, connectivity, specific surface and surface contact, directly drive ion diffusions and electronic conductivities as well as electrochemical reactions. Furthermore, the coupling between absorption and phase contrast modes (in X-ray imaging) is always required to identify each phases containing heavy and light elements. Tomography reconstruction steps have to be then optimized as so to minimize artifact and noise as well as get high contrast. Tomopy, an open-source Python package developed by ID32 beamline from APS synchrotron (Argonne NL, USA), is used for tomographic data processing and image reconstruction: rotation center determination, phase retrieval, tomogram reconstruction (via CPU or GPU) **[2]**.

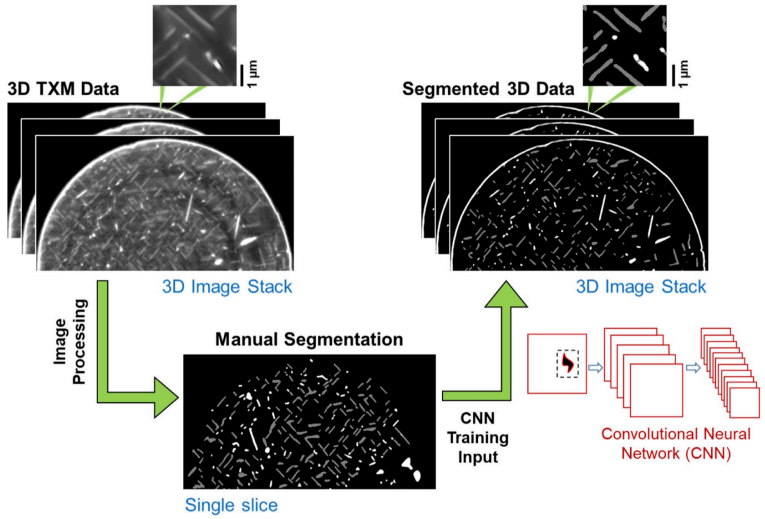

Figure1 : Schematic showing workflow of the segmentation process on TXM datasets using a deep learning (Convolutional Neural Network) approach [4].

Complexity of these composite features as well as presence of multiple phases demands careful segmentation in order to get usable data for 3D analysis. Machine learning **[3]** provides a robust solution to automate segmentation processes by learning from existing model data relationships and is suitable to analyze of high-dimensional complex data problems. Its implementation in this field can make segmentation almost an entirely automated process. Among different approaches, convolutional neural network (CNN) **[4]** is a popular deep learning technique for image processing. It is capable of classifying structural features in images similar to the way the human visual system operates. Its accuracy and efficiency for feature recognition and classification have been proved for various applications. Different hierarchical levels of the trained network are used to identify features of varying complexity. The trained network is then used to segment the entire 3D image stack.

3D reconstructions will be performed using Tomopy and specific libraries for filtering. Subsequent 3D segmentation, quantification and visualization will be carried out in Avizo and FIJI softwares. A Python toolbox named Xlearn [5] was used to implement the CNN model. The project will focus on several types of Li-ion batteries such as Li-air, Li-S and all-solid-state battery.

References:

[1] Pietsch, P., & Wood, V. (2017). X-ray tomography for lithium ion battery research: a practical guide. *Annual Review of Materials Research*, *47*, 451-479. **[2]** Gürsoy D, De Carlo F, Xiao X, and Jacobsen C. Tomopy: a framework for the analysis of synchrotron tomographic data. *Journal of Synchrotron Radiation*, 21(5):1188–1193, 2014. **[3]** Yang, X., De Andrade, V., Scullin, W., Dyer, E. L., Kasthuri, N., De Carlo, F., & Gürsoy, D. (2018). Low-dose x-ray tomography through a deep convolutional neural network. *Scientific reports*, *8*(1), 2575. **[4]** Kaira, C. S., Yang, X., De Andrade, V., De Carlo, F., Scullin, W., Gursoy, D., & Chawla, N. (2018). Automated correlative segmentation of large Transmission X-ray Microscopy (TXM) tomograms using deep learning. *Materials Characterization*, *142*, 203-210. [5] https://github.com/tomography/xlearn.