

## PhD Thesis – MEB-3D project

Job title	Deep learning for the denoising and restoration of images from a scanning electron microscope for the 3D metrology of microstructures
Job type (PhD, Post-doc, Engineer)	PhD
Contract	36 months 1600 € net/month
Qualifications (Master, Ph.D ...)	Master
Job hours (full time/ part time)	Full Time
Employer	UBFC Université Bourgogne Franche-Comté
Financing Institutions	Graduate School EIPHI & Region Bourgogne Franche Comté
Host Laboratory	FEMTO-ST Institute, UMR CNRS 6174, Belfort (France)
URL Host Laboratory	<a href="http://www.femto-st.fr">www.femto-st.fr</a>
Address Host Laboratory	FEMTO-ST – DISC – IUTBM – UFC (Belfort IUT-BM) 19 avenue du Maréchal Juin - BP 527, 90016 Belfort Cedex, France Applicant will be hosted by the AND team of the DISC (Computer Science) department located in Belfort at IUT Belfort-Montbéliard with some stays at the AS2M department located in Besançon.
Job description	<p><b>Context:</b> The PhD grant is associated with the project MEB-3D funded by EIPHI Graduate School. MEB-3D stands for “Microscopie électronique à balayage tridimensionnelle sûre pour les applications métrologiques et éducatives” (in French) or “Safe three-dimensional scanning electron microscopy for metrological and educational applications” (in English). The abstract of the project, which is managed by Michel Salomon, is described below.</p> <p><b>Abstract:</b> Scanning electron microscopy (SEM) is an imaging technique commonly used for the microstructural characterization of materials. Indeed, this technique produces high-resolution images that allow to observe and measure geometries of samples. However, SEM only delivers two-dimensional images. It is therefore necessary to use computers to construct three-dimensional images of samples if one wants to access their three-dimensional geometries. But, most importantly, images produced by SEM are subject to noise and degradation with respect to operational settings, particularly scan speed. On one hand, a slow scan speed reduces noise level, but can lead to the deterioration of the samples, especially when they are fragile. On</p>

the other hand, a fast scan speed protects samples but generates high level of noise [1]. Considering the latter case, to obtain reconstructed 3D images that can be used for metrology, the visual quality of images must be improved by denoising and restoring them. The thesis aims to study deep learning approaches for SEM images denoising and restoration, which will then be implemented on the SEM of the lab and validated by the 3D metrology of samples considered in the project.

Main objective and proposed work during the thesis:

Deep Learning for image denoising and restoration is the subject of many research works. However, in the context of electron microscopy this is a original approach, as the trend is towards compressed acquisition, like what has been done for tomographic images. Unfortunately, electron microscopy does not respect the conditions of sparsity. A first challenge will therefore be the design and training of a deep neural network in the context of scanning electron microscopy. For this, two approaches are possible, a supervised approach or an unsupervised one. The first assumes a database with noisy images and their noiseless/restored counterpart, while in the second only noisy images from SEM are needed for training. In the context of images produced by SEM, a supervised approach will involve being able to characterize the noise, which will be a second challenge. An unsupervised approach will be a challenge due to the absence of reference noisy images. The objective of the thesis is thus to study the state of the art in image denoising and restoration by deep learning, then to design supervised and unsupervised approaches taking advantage of the project partners to produce a dataset of images. And finally, to validate the results by using them for three-dimensional reconstruction of partners samples: pollen grains, powder grains, microrobotic components, textured components. In the supervised framework, we will particularly rely on some of the work already carried out within the DISC (the AND team involved in MEB-3D has been working for 5 years on deep learning approaches), consisting of a U-Net encoder-decoder with skip connections which already makes it possible to process different types of noise, with blind denoising capacities, and performances like well-known approaches in the field [2].

[1] A. Kudryavtsev, S. Dembélé, N. Piat; "Autofocus on Moving object in Scanning Electron Microscope"; Ultramicroscopy Vol. 182, 216-225, 2017.

[2] R. Couturier, G. Perrot, and M. Salomon, "Image Denoising Using a Deep Encoder-Decoder Network with Skip Connections". In 25th International Conference on Neural Information Processing (2018), vol. 11306, Series Lecture Notes in Computer Science (LNCS), pp. 554-565, 2018.

Planned activities

First step (16 months):

State of the art on denoising and restoration of images

	<p>Characterization of the noise in images from the SEM of ROBOTEX platform          Design of a supervised deep learning model          Second step (10 months):          Design of an unsupervised deep learning model          Third step (10 months):          Validation of approaches for 3D reconstruction and metrology of project's samples          Dissertation/manuscript writing</p>
Supervisor(s)	<p>Michel Salomon (Associate Professor of Computer Science, UFC; FEMTO-ST – DISC, Belfort) - supervisor, michel.salomon@femto-st.fr          Soukalo Dembéle (Associate Professor of Computer Engineering, UFC; FEMTO-ST - AS2M, Besançon) - co-supervisor, soukalo.dembele@femto-st.fr</p>
Candidate profile	<p>We are looking for a highly motivated master student in computer science or equivalent qualification with excellent results, who is interested in working on deep learning for denoising/restoring of images obtained from a scanning electron microscope.</p> <p>Applicants should have experience with neural networks, more particularly deep networks, and computer programming frameworks for deep learning using Python (Google TensorFlow, PyTorch, or Keras). Knowledge in deep learning approaches for image denoising/restoration would also be an advantage. Reasonable proficiency in English (written and spoken) is a requirement.</p> <p>Interpersonal skills, dynamism, rigor and teamwork abilities will be appreciated. Candidates can be fluent either in English and/or in French.</p>
Keywords	<p>Deep learning, Image denoising/restoration, Scanning electron microscopy, Metrology of microstructures</p>
Application deadline	<p>15/06/2021</p>
Application Depending on the type of position	<p>Please send the following documents (all in one PDF file) by e-mail to <a href="mailto:job-application@ubfc.fr">job-application@ubfc.fr</a> with copy to supervisors:</p> <ol style="list-style-type: none"> <li>1) For EU candidates: Copy of your national ID card or of your passport page where your photo is printed. For non-EU candidates: Copy of your passport page where your photo is printed.</li> <li>2) Curriculum Vitae (1 page).</li> <li>3) Letter of motivation relatively to the position (1 page).</li> <li>4) Copy of your Master degree if already available.</li> <li>5) Copy of your final marks and ranks.</li> <li>6) Coordinates of reference persons (maximum 3, at least your master thesis supervisor): Title, Name, organization, e-mail.</li> </ol> <p>If you have questions regarding the application, please contact the supervisors.</p>