Context:
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.

Abstract:
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
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 an 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].


Planned activities
First step (16 months):
State of the art on denoising and restoration of images
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

Supervisor(s)
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Candidate profile
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.

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.

Interpersonal skills, dynamism, rigor and teamwork abilities will be appreciated. Candidates can be fluent either in English and/or in French.

Keywords
Deep learning, Image denoising/restoration, Scanning electron microscopy, Metrology of microstructures

Application deadline
15/06/2021

Application Depending on the type of position
Please send the following documents (all in one PDF file) by e-mail to job-application@ubfc.fr with copy to supervisors:

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.
2) Curriculum Vitae (1 page).
3) Letter of motivation relatively to the position (1 page).
4) Copy of your Master degree if already available.
5) Copy of your final marks and ranks.
6) Coordinates of reference persons (maximum 3, at least your master thesis supervisor): Title, Name, organization, e-mail.

If you have questions regarding the application, please contact the supervisors.