Deep learning-based techniques for image analysis on TEM and SEM imagery

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Deep learning continues to push the boundaries of computer vision and understanding of myriad applications from self-driving cars to medical image analysis. The application of combined machine and deep learning-based techniques in nano-scale research and development, can lead to great efficiency, particularly in the domain of microscopy image analysis and measurement. The clear limitation of these approaches is the requirement for large quantities of labelled data, which is often time-consuming and expensive to produce.

Our framework allows users to create their own ML model easily. This model is used for image measurements applying different tools available for image processing, including deep learning. Positive examples of objects to measure are used to train the model. It is very important to include margin entities as input to the framework to cover a wider deformation. Finally, the resulting model can be applied on other similar structures, replicating the customized measurements on other images.

We present two elements of this framework designed to work alongside experts. The first is to apply deep object detection to push further the robustness to deformations and the cross-design learning in TEM/SEM domain. Then based on the object detection, we propose an instance based segmentation method to also recover the boundaries of objects, achieving promising performance, especially considering the limited quantity of labelled data supplied.

There are two main challenges in our context. The first one is the quantity of annotated data required to achieve an acceptable performance. Currently, applications usually require thousands of examples. We show that it is possible to use less annotations and use different methods to efficiently gather annotations. The second challenge is to propose a training procedure to non deep learning expert users.

The process and performance is demonstrated on selected examples from our internal data in semiconductor and non semiconductor applications. We used labelled examples for re-training, followed by benchmarking on a larger test set manually annotated for this project. The role of these components within the overall framework is then described, demonstrating how a process engineer or scientist can accelerate their development process with a combination of semi-automatic and automatic measurements on their batches.

Short Abstract:

The application of combined machine and deep learning-based techniques in nano-scale research and development, can lead to great efficiency in the domain of microscopy image analysis and measurement. This paper will explain and present our framework apply to selected examples from our internal data in semiconductor and non-semiconductor applications.