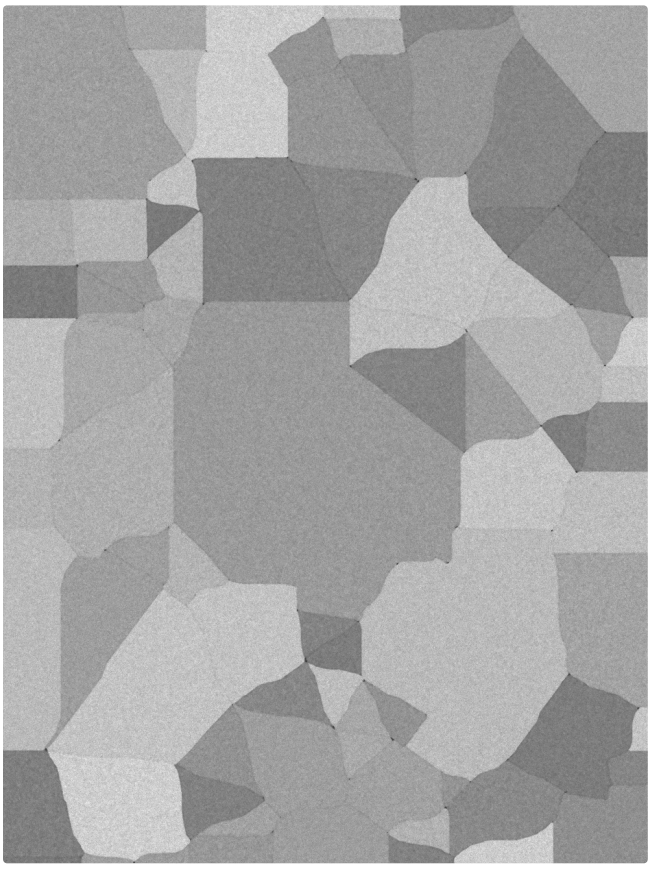
MLE Interview Assignment: Crystal Grain Segmentation

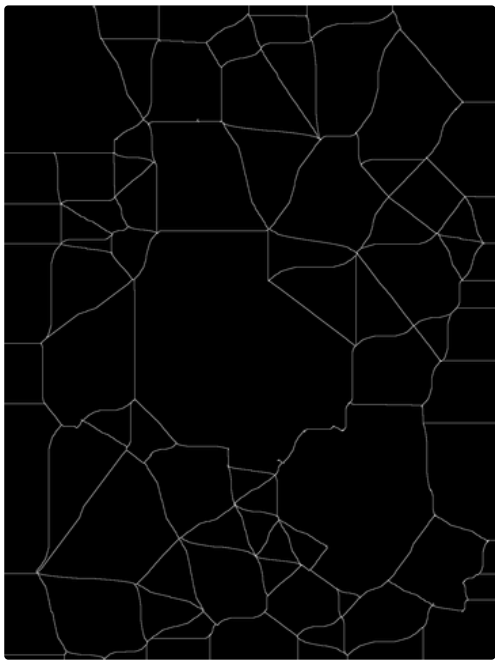
Background

Metals and ceramic materials are composed of individual crystal grains. When viewed with a high magnification microscope, individual grains can show contrast depending on their crystallographic orientation, allowing one to distinguish individual grains. Grain size influences physical behavior, specifically mechanical and electrical properties. We often want to understand what the grain size distribution looks like from one batch of materials to the next.

Recently the engineers from the Metrology team developed a high-magnification imaging tool for grains (see image from that tool on below left). They also tried to use traditional image processing techniques to generate segmentation maps for the grain boundaries. However, they worried that the human-picked algorithms and parameters might not generalize well for future batches of materials due to changing lighting intensity, contrast, and texture. They reached out to the software team to see if they could provide a deep learning based solution which hopefully will be more robust in the long term. They also labeled the grain boundary on a couple of images (example on below right).



Grain image



Segmentation mask representing the grain boundary

Objective

As part of the MLE team, your task is to develop a deep learning based model that predict the grain boundaries. The input of the model is the grain images, and the output is the segmentation masks that represents the grain boundary.

Given the limited dataset, the goals is to produce a “minimal viable product” that shows if the deep learning approach can work, rather than trying to push the accuracy as high as possible.

Data

5 grain images with manually labeled segmentation maps

- 4 images for training
- 1 image for validation

Success Criteria

1. Model performance which is measured by intersection over union (IoU) between the labeled grain boundary and predicted grain boundary
2. Selected model architecture and its relevance to the type of problem
3. Overall organization of the code and readability

Deliverables

1. Predicted segmentation mask and IoU score on validation image
2. Zipped file containing the code for the work
3. After the assignment is delivered via email, you have up to 48 hrs to email back the solution.

FAQ

- Is it allowed to include traditional image processing algorithms as part of the solution?
  - Yes. However note that the main objective of this assignment is to access skills related to deep learning. A pure traditional image processing based solution would not be accepted even if it can achieve high performance with provided data.
- Is it OK to use online/AI based tools (e.g. Google, ChatGPT) to help with the solution?
  - Yes. This is an open-book assignment and researching/adopting relevant techniques is encouraged. However please cite relevant sources (and for AI generated code make an note in comment indicating code generated by XYZ tool) if it more than 2~3 lines of code are taken directly from online sources and/or AI tools. Copied code without proper citation will not be accepted.
- Which programming language/ML framework is allowed?
  - Python + PyTorch is preferred; but other languages/framework are allowed as well.