Automating the Segmentation of X-ray Images with Deep Neural Networks

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Motivation

In recent years, the use of X-ray tomography has been accelerating with applications in, for example, material science and the medical industry. Within these fields, there is a large demand for the ability to segment the X-ray images rapidly. The automation of this segmentation process could reduce human intervention requirements, which is typically prone to error.

This project aims to automate the image segmentation process by utilising Deep Neural Networks (DNN).

Background

As mentioned, image segmentation often relies on human intervention. An obvious choice when performing image segmentation is to implement a multi-threshold segmentation, relying on the intensity distribution within the image. However, previous attempts have shown that simply thresholding intensity distributions is not sufficient to effectively segment X-ray images.[1]

This realisation has paved the way for the field of DNNs. One method that proved its efficiency in image segmentation of mammogram and SOFC X-ray images is the U-Net.[2, 3] This U-Net approach utilises convolution, pooling layers and upsampling to perform image segmentation. The advantage of the U-Net is its incorporation of information from low resolution images with many channels and higher resolution images with fewer channels. This method enables the combination of both global and local information in the feature maps.

[1] De Angelis, Salvatore, et al. “Three Dimensional Characterization of Nickel Coarsening in Solid Oxide Cells via Ex-Situ Ptychographic Nano-Tomography.” Journal of Power Sources, vol. 383, Elsevier B.V., 2018, pp. 72–79, doi:10.1016/j.jpowsour.2018.02.031.

[2] Pan, Shuwan, et al. “X-Ray Mammary Image Segmentation Based on Convolutional Neural Network.” 2019 Ieee 4th International Conference on Image, Vision and Computing, Icivc 2019, Institute of Electrical and Electronics Engineers Inc., 2019, pp. 105–08, doi:10.1109/ICIVC47709.2019.8981350.

[3] Anna Sciazko et al. “3D microstructures of solid oxide fuel cell Ni-YSZ anodes with carbon deposition”, Chemical Engineering Journal, Volume 460, 2023, https://doi.org/10.1016/j.cej.2023.141680.

Milestones

Timeline	Milestones	Notes
Week 9 (30/10-5/11)	☑ Write synopsis ☑ Intro meeting with supervisor ☑ Get access to data ☑ Theory recap	Brainstorming different image segmentation methods, searching in literature for inspiration.

Week 10
(6/11-12/11)
	☐ Data preparation
	  ☐ Initial visualisation
	  ☐ Data augmentation
	☐ Start U-Net setup
		Data augmentation if required, conduct initial data overview.
		
		Generally, writing conclusions from each week in the report.

Week 11 (13/11-19/11)	☐ Get initial segmentation from U-Net ☐ Improve model ☐ Setup accuracy check against GT	Setup standard U-Net, and improve with different network setups. Verify the initial output with the ground truth (GT). If there is time, create a setup for this accuracy check. Generally, writing conclusions from each week in the report.
Week 12 (20/11-26/11)	☐ Test another method ☐ e.g. VNet, VGGNet ☐ Setup hyper parameter test ☐ Compare with U-Net	Test and compare method outputs with U-Net. Test different hyper parameter combinations. Generally, writing conclusions from each week in the report.
Week 13 (27/11-3/12)	☐ Make poster ☐ Fine tune images for poster	Mostly using time to create the poster and practise for presentation. Generally, writing conclusions from each week in the report.

Exam period
(4/12-21/12)
	☐ Poster presentation
	  ☐ Make corrections in report accordingly
	☐ Fine tune report
	  ☐ Fine tuning models
	  ☐ Fine tuning images
		Make corrections in the report according to feedback from the presentation.
		
		Fine tune models (if needed), but focus on finishing the report in time.