An interactive deep learning segmentation software with sparse annotations

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Introduction

- Deep learning segmentation yields unprecedented results. Unfortunately, the images and objects to segment can be very different from one application to the other. Pre-trained models might behave poorly on new applications.
- We explore the feasibility of online training of a convolutional neural network from scratch with annotations given on the fly. We designed a user-friendly graphical interface that allows sketching a few zones of interest and training various architectures.
- Starting from random weights, the neural network adaptively learns to segment the objects of interest with the user provided corrections. In the spirit of deep image prior [UVL18], we show that for various applications very few annotations are enough to train lightweight networks.

Data

- The data can be a 2D grayscale or RGB image, whatever the format.
- The interface is trained on a single image and processes it.

Comparisons with Ilastik - Synthetic data

A software with a very similar spirit, but different back-bone is Ilastik [SSKH11].

Can this approach differentiate shapes, textures, colors?

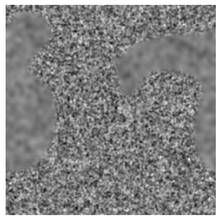

Figure 1: Example of textures

Figure 2: Example of shapes

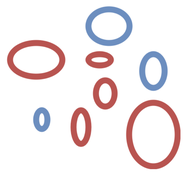

Figure 3: Example of colors

For our method, we used a randomly initialized U-Net composed of a single layer of 64 filters of size 5 and of a skip connection composed of 10 filters of size 5 too.

	Ilastik	Our method
Textures	0.97	0.94
Shapes	0.98	0.98
Colors	0.97	0.94

Table 1:Comparison of the performances of Ilastik and our method in terms of DICE

The neural network has a DICE similar to Ilastik, with a small decrease related to less precise edges. Yet, it returns far less spurious details and more pleasant details.

Comparison with Ilastik - Real data

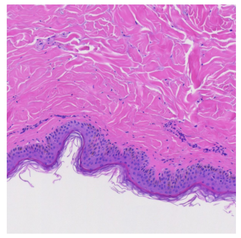

Figure 4: Histology example

Figure 5: Labels

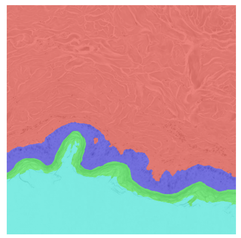

Figure 6: Our result

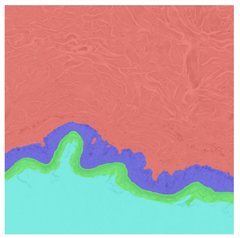

Figure 7: Ilastik result

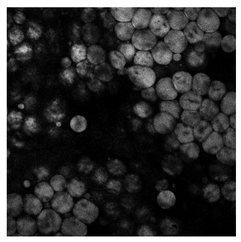

Figure 8: Cells example

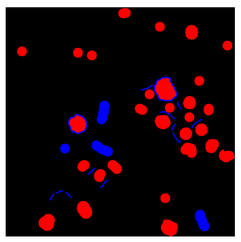

Figure 9: Labels

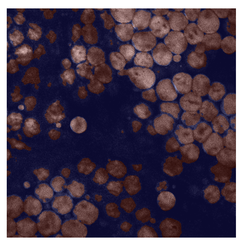

Figure 10: Our result

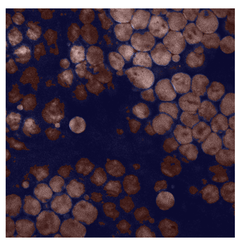

Figure 11: Ilastik result

The histology image has been processed using a 4-layer network whereas 2 layers were sufficient to process the cells image.

Conclusion & Future Work

- A simple CNN trained from very few annotations starting from random weights provides results which are on par with more established random forest models.
- Contrarily to popular beliefs, very small amount of annotation might be enough to train neural nets for simple tasks.
- The design of problem-dependent architecture (e.g. edge, filaments, dots detection) is a difficult issue, yet to be explored.
- From a computation time point of view, Ilastik [SSKH11] is for now faster (2,3 ×).
- A possible solution to improve the segmentation of contiguous objects such as cells would be to develop an architecture based on heat maps similar to the one of Cellpose [SWMP21].
- Another great feature we would like to add would be the 3D image processing.
- Napari integration looks natural and might come soon.

Related Work

[SSKH11] Christoph Sommer, Christoph Straehle, Ullrich Koethe, and Fred A Hamprecht, *Ilastik: Interactive learning and segmentation toolkit*, 2011 IEEE international symposium on biomedical imaging: From nano to macro, IEEE, 2011, pp. 230–233.

[SWBM18] Uwe Schmidt, Martin Weigert, Coleman Broaddus, and Gene Myers, *Cell detection with star-convex polygons*, Medical Image Computing and Computer Assisted Intervention - MICCAI 2018 - 21st International Conference, Granada, Spain, September 16-20, 2018, Proceedings, Part II, 2018, pp. 265–273.

[SWMP21] Carsen Stringer, Tim Wang, Michalis Michaelos, and Marius Pachitariu, *Cellpose: a generalist algorithm for cellular segmentation*, Nature Methods **18** (2021), no. 1, 100–106.

[UVL18] Dmitry Ulyanov, Andrea Vedaldi, and Victor Lempitsky, *Deep image prior*, Proceedings of the IEEE conference on computer vision and pattern recognition, 2018, pp. 9446–9454.

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