U-Net for Medical Image Segmentation

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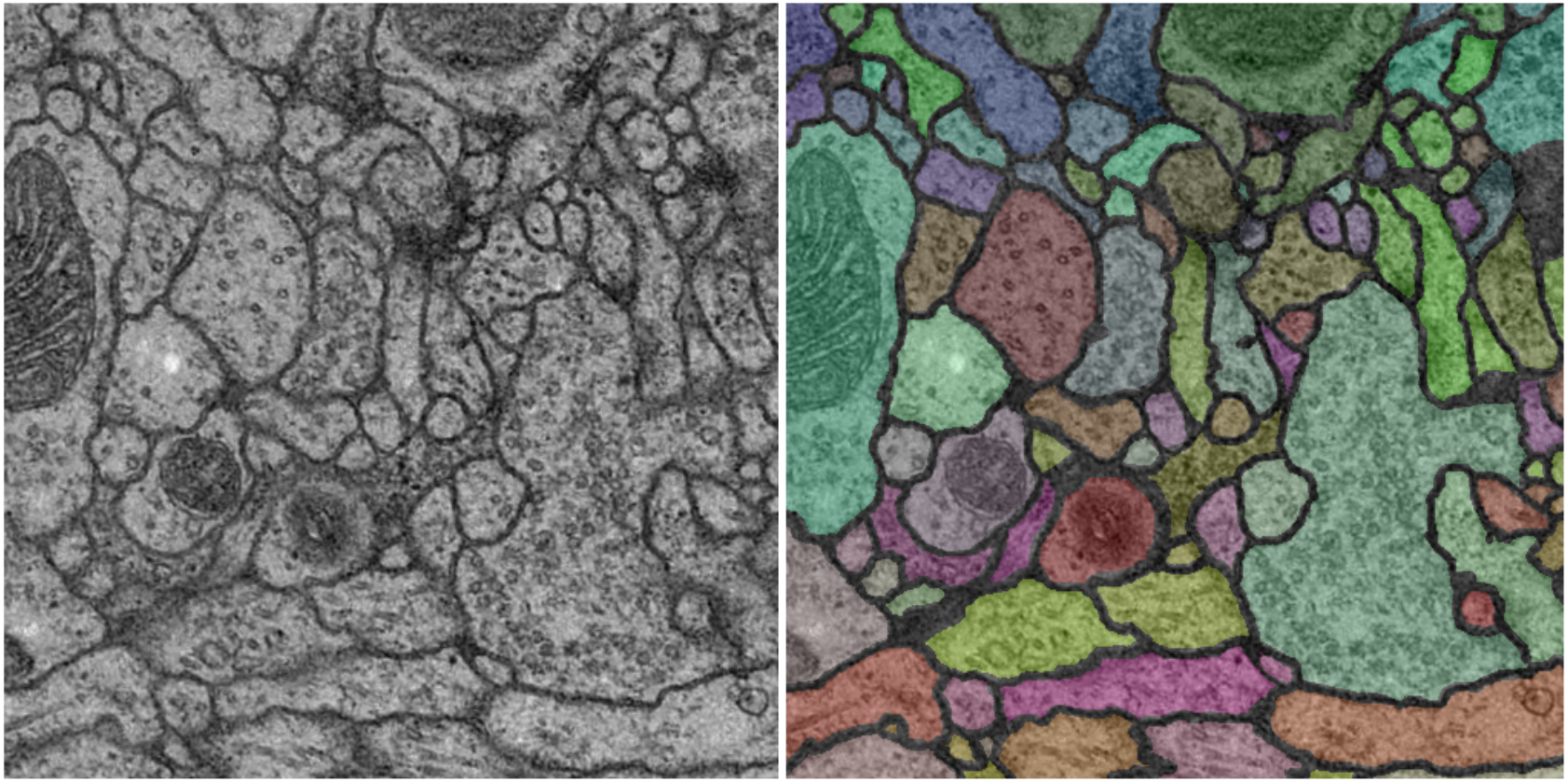
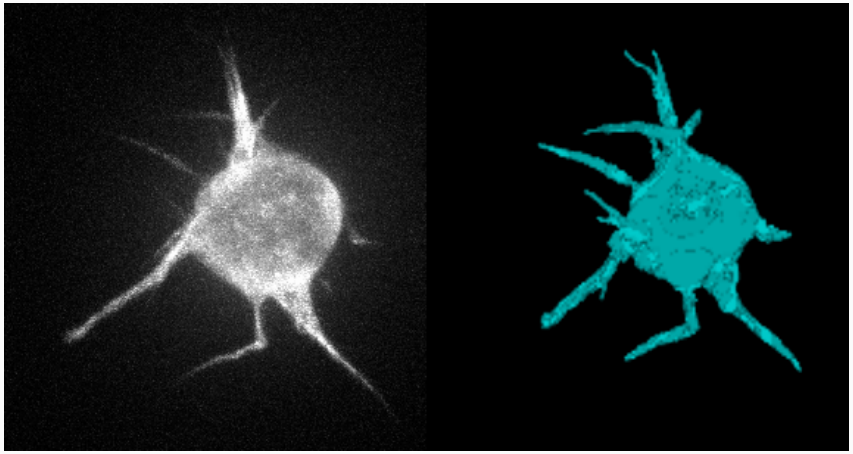
Problem Description

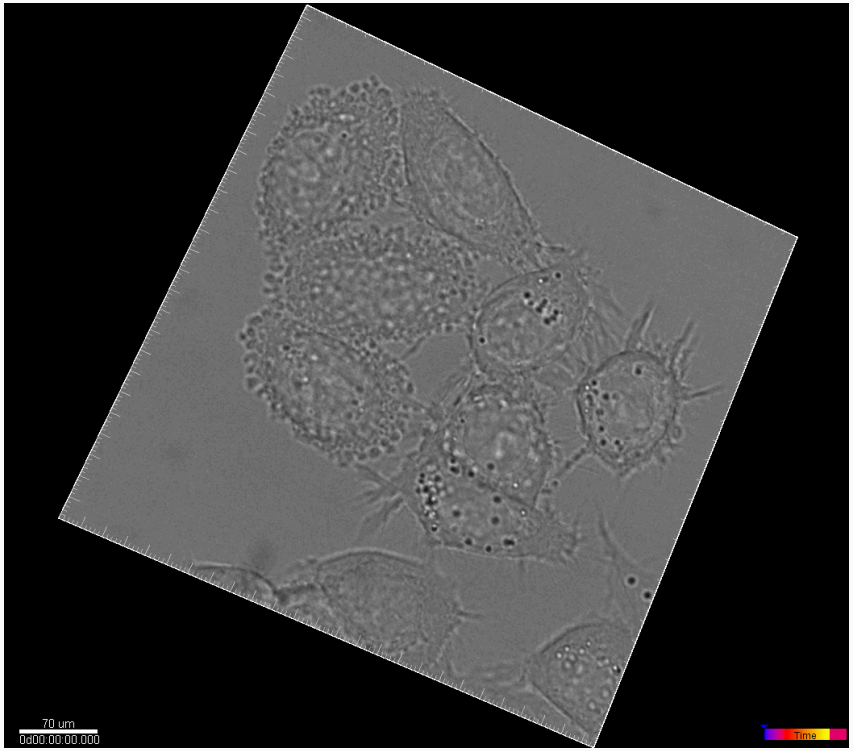
Segmentation of Neural Structures



[1]

Cell Tracking





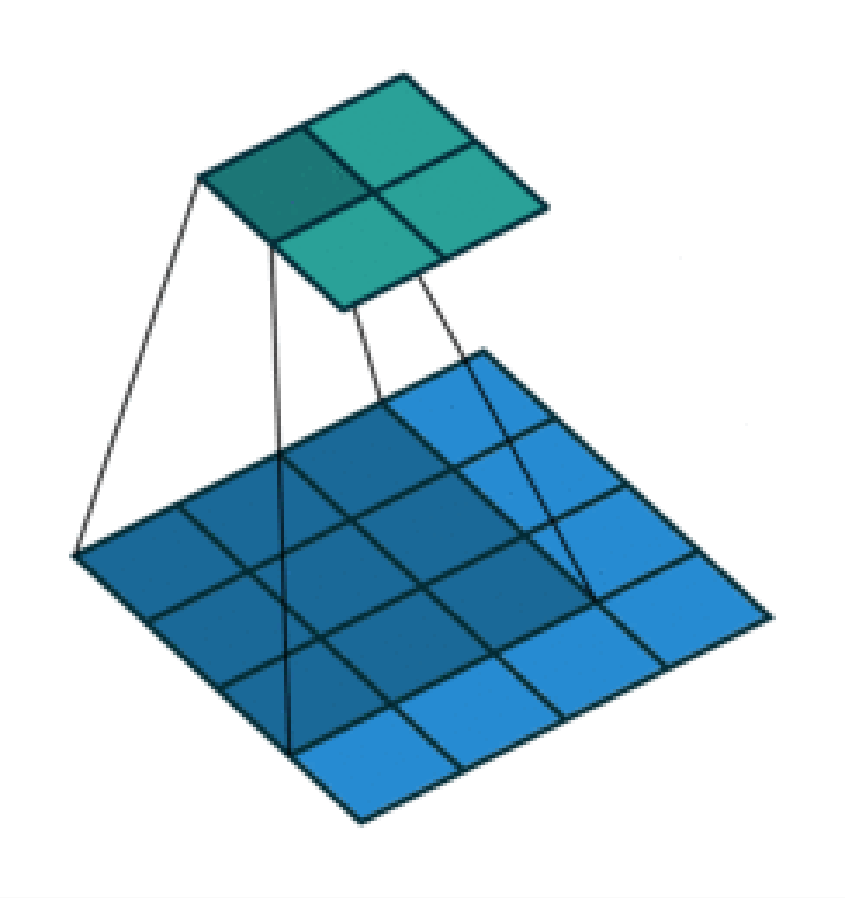
[3]

Main Challenges

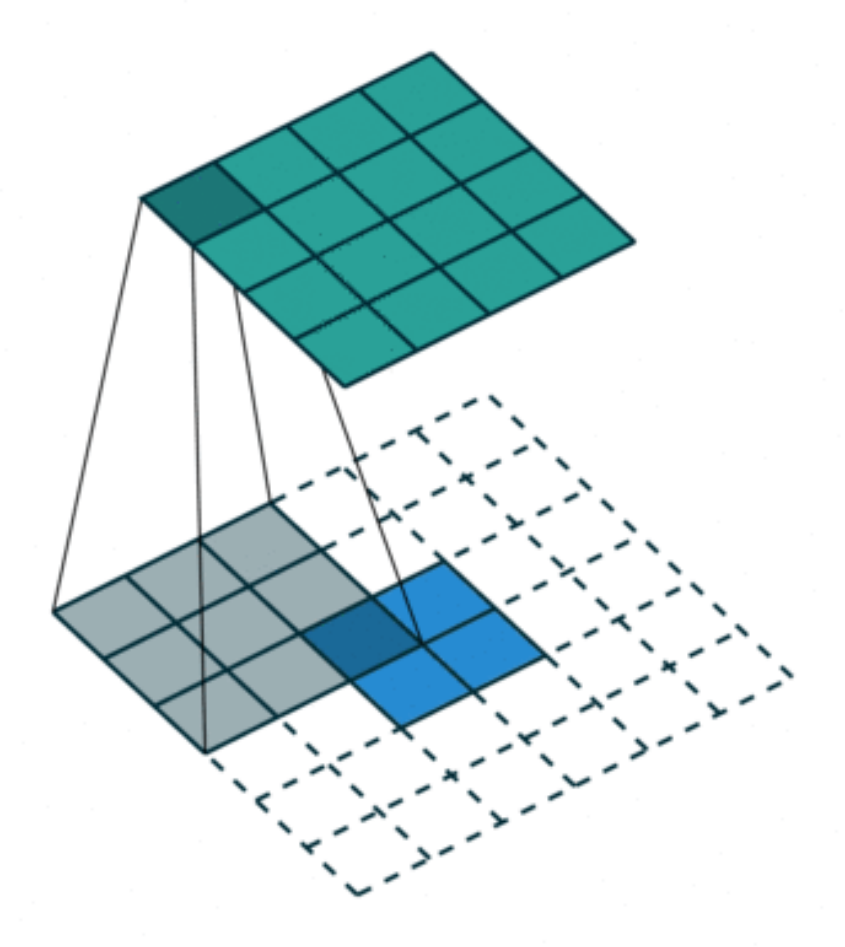
- Small Datasets (only 30 training images provided)
- Touching objects of the same class

Convolution and Up-Convolution

Convolution

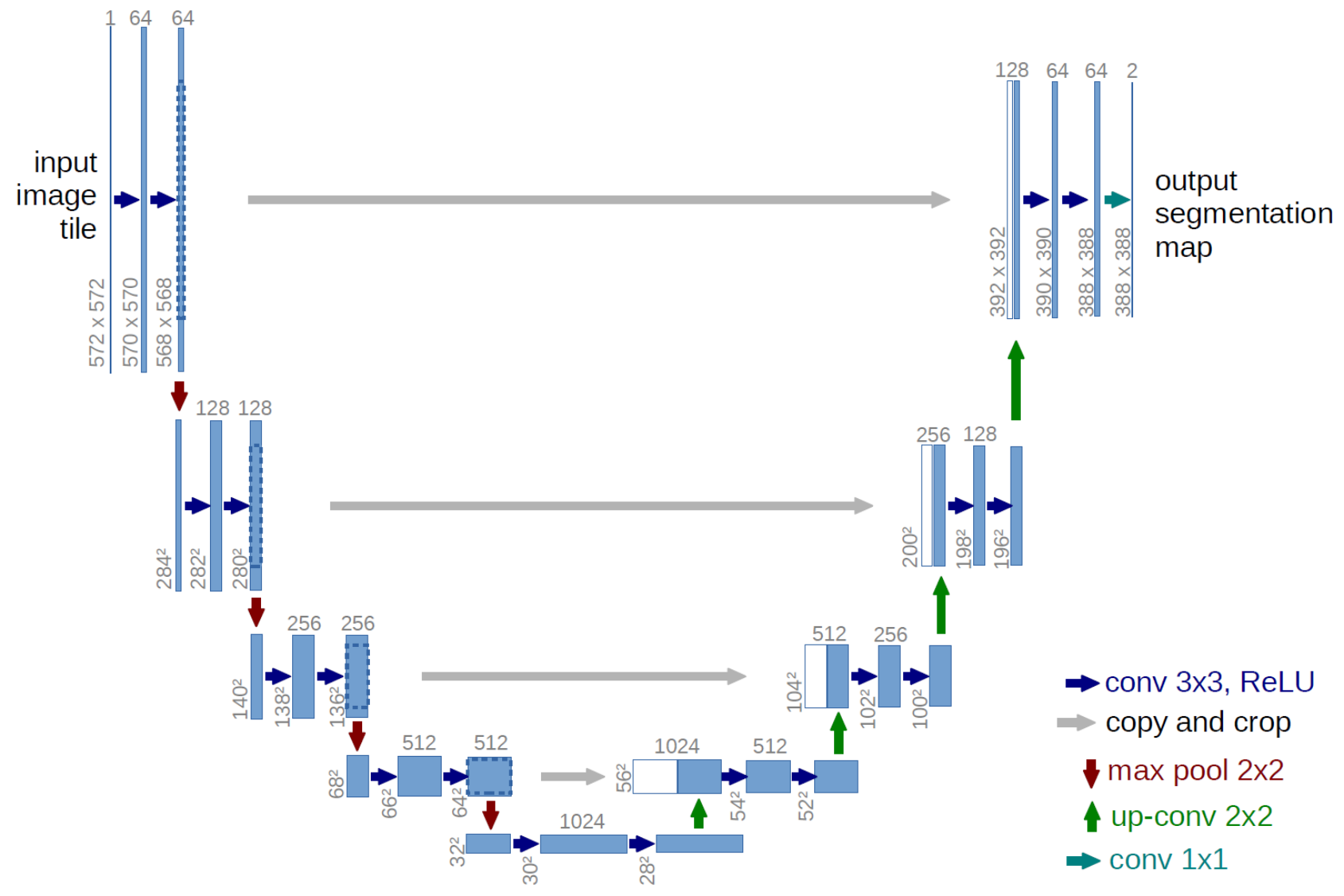


Up-Convolution



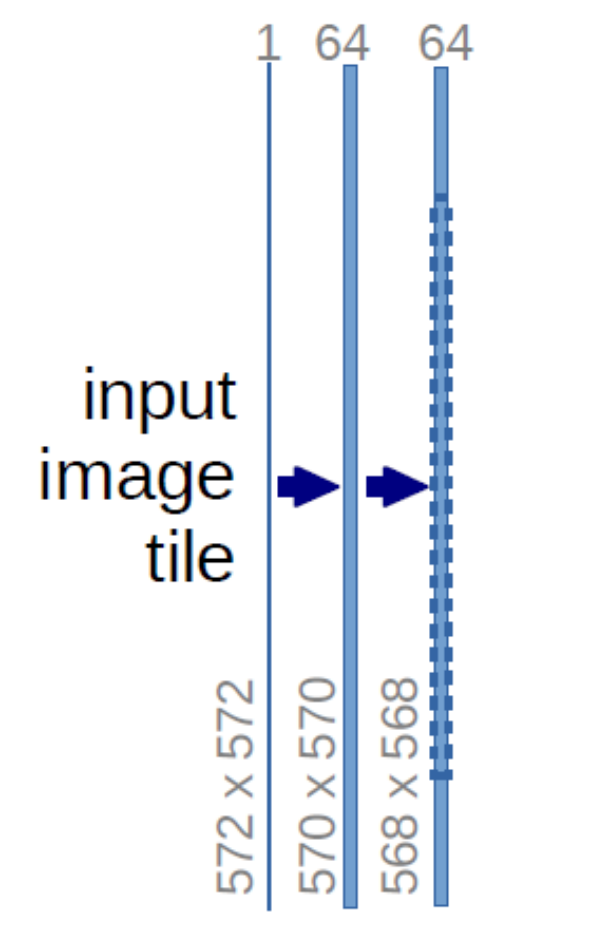
Architechture of U-Net

U-Net Architecture (Overview)

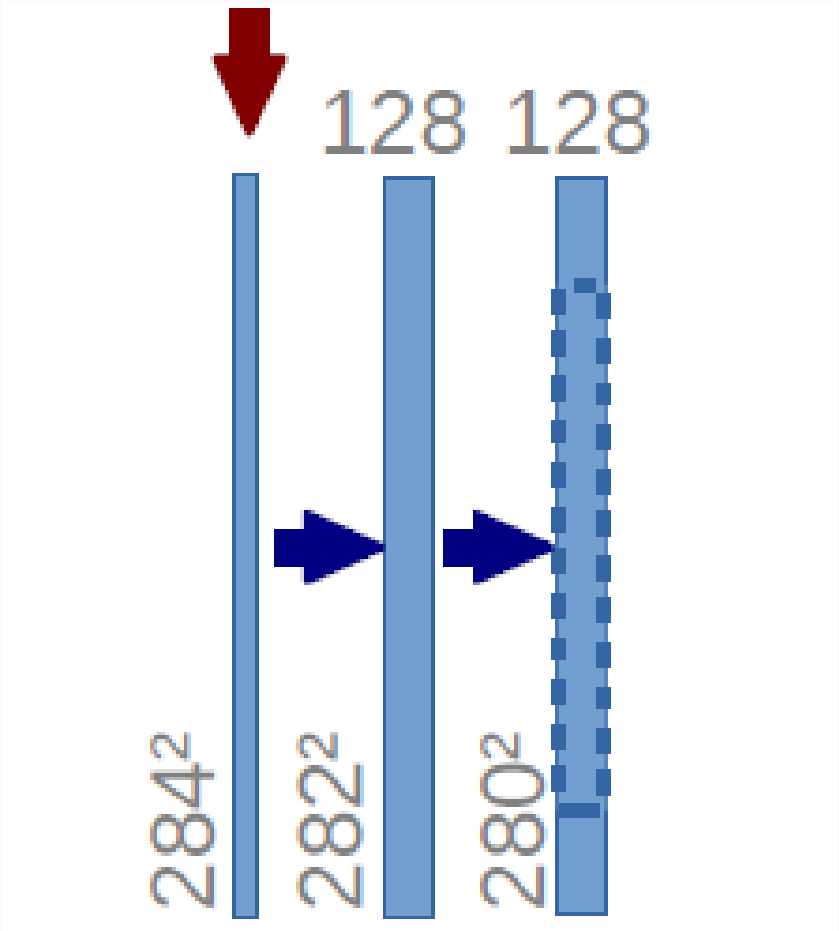


[2]

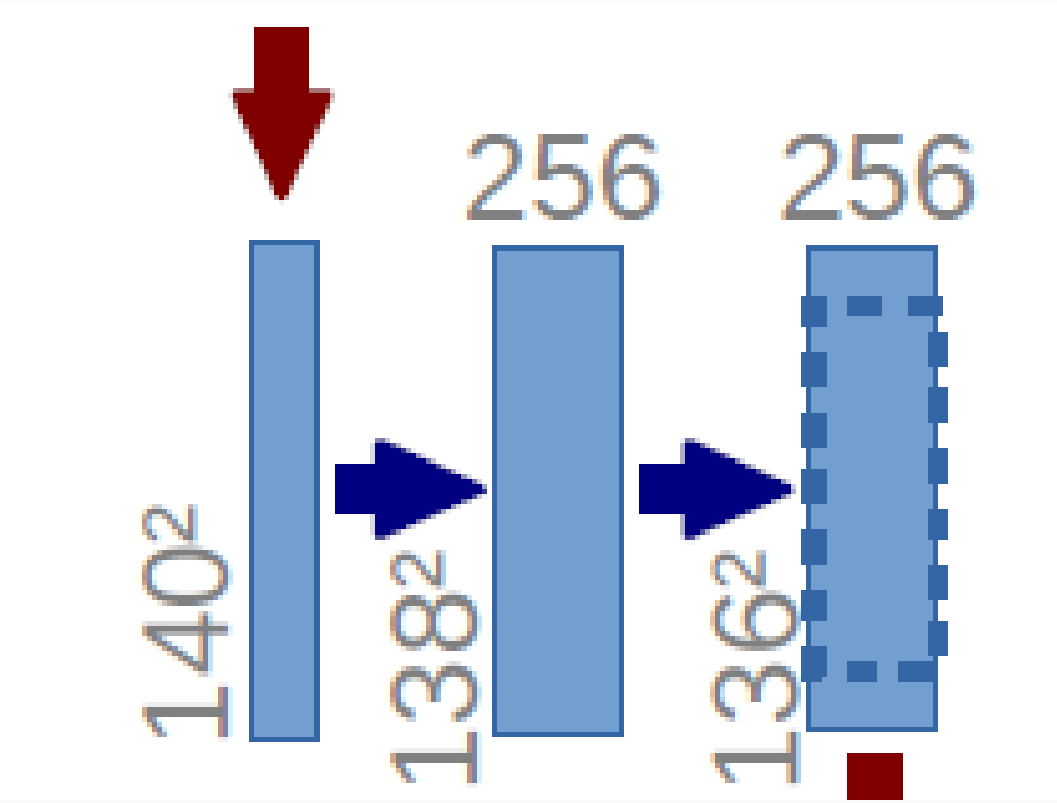
U-Net Architecture (Contracting)



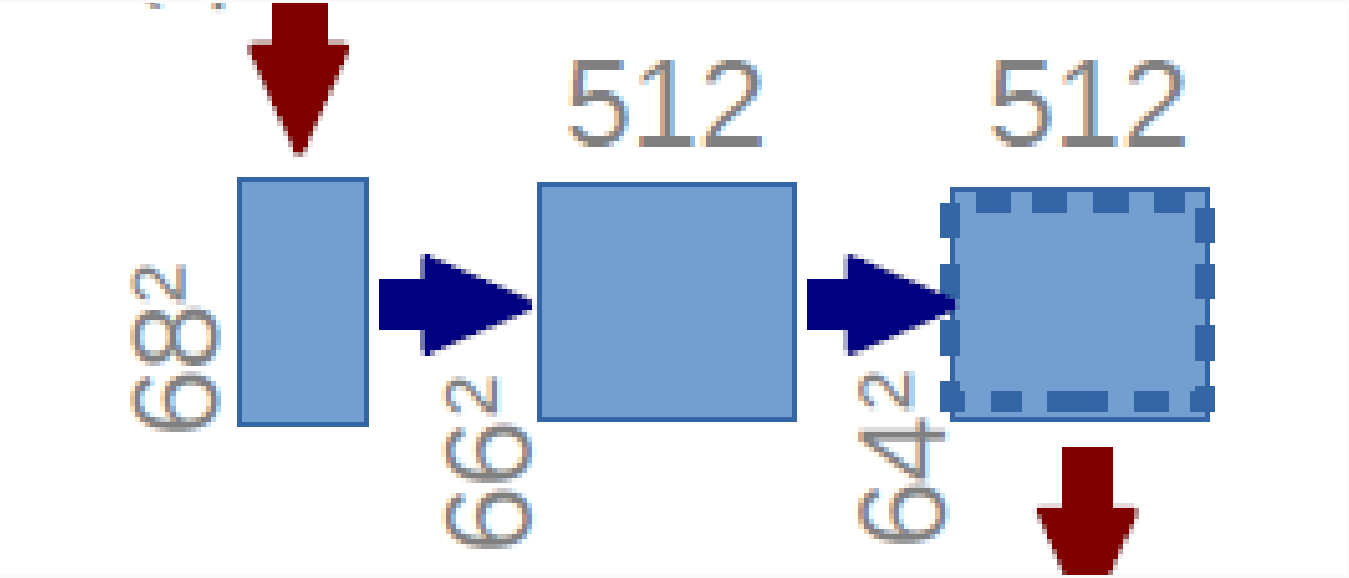
U-Net Architecture (Contracting)



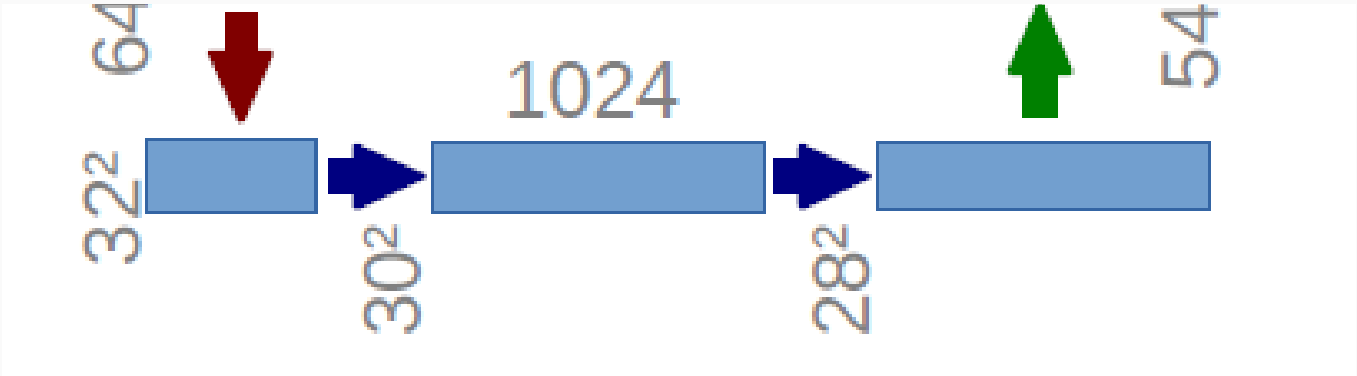
U-Net Architecture (Contracting)



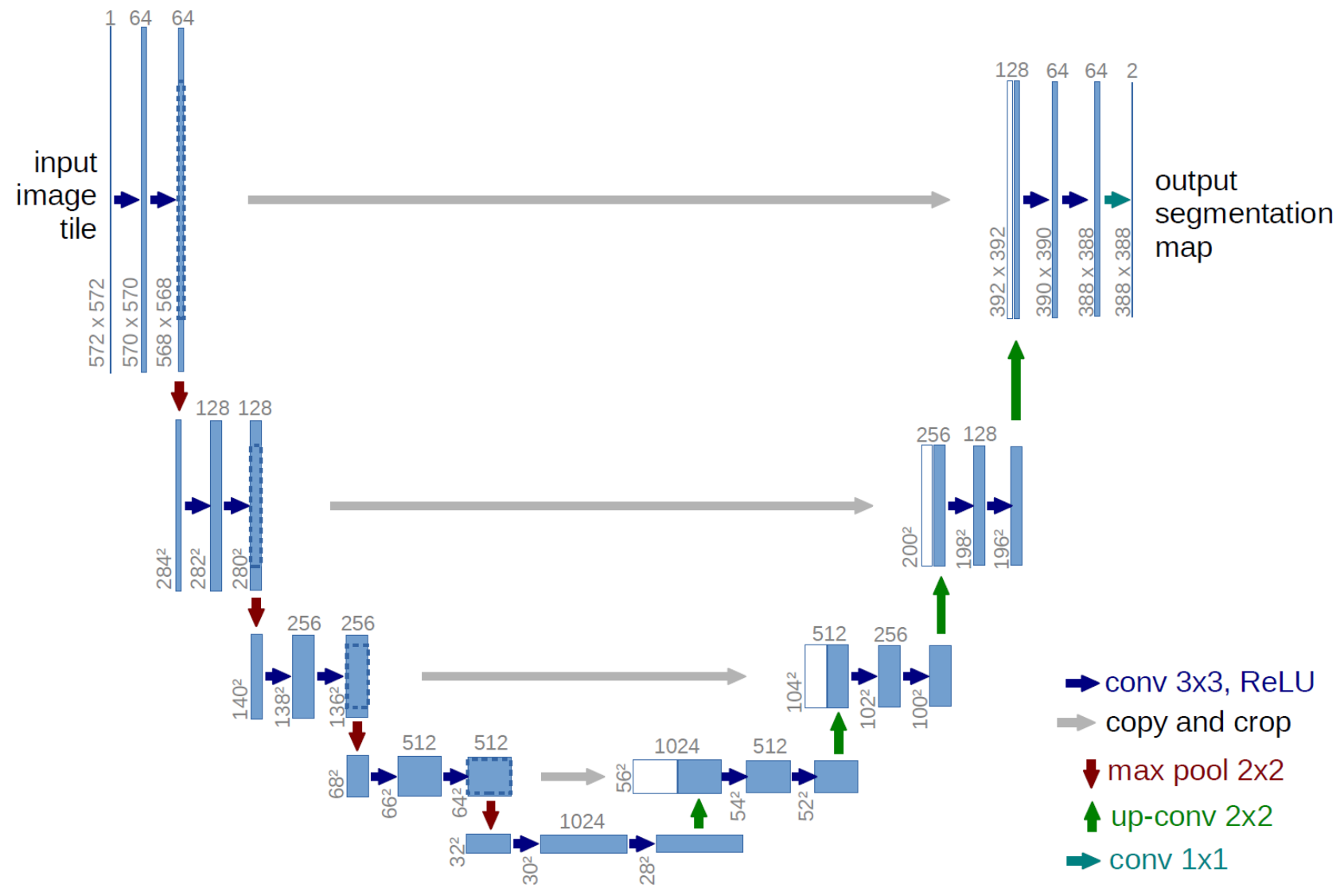
U-Net Architecture (Contracting)



U-Net Architecture (The Bottom)

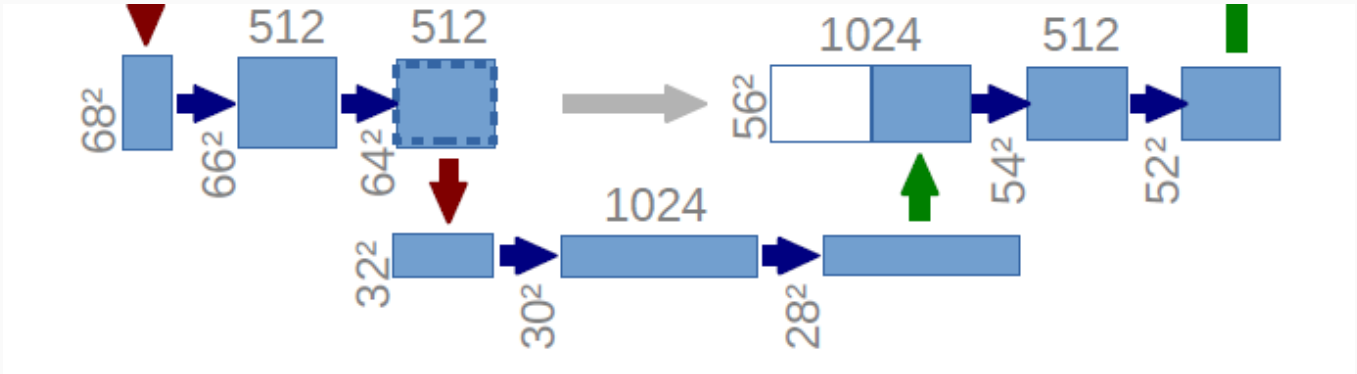


U-Net Architecture (Recap)

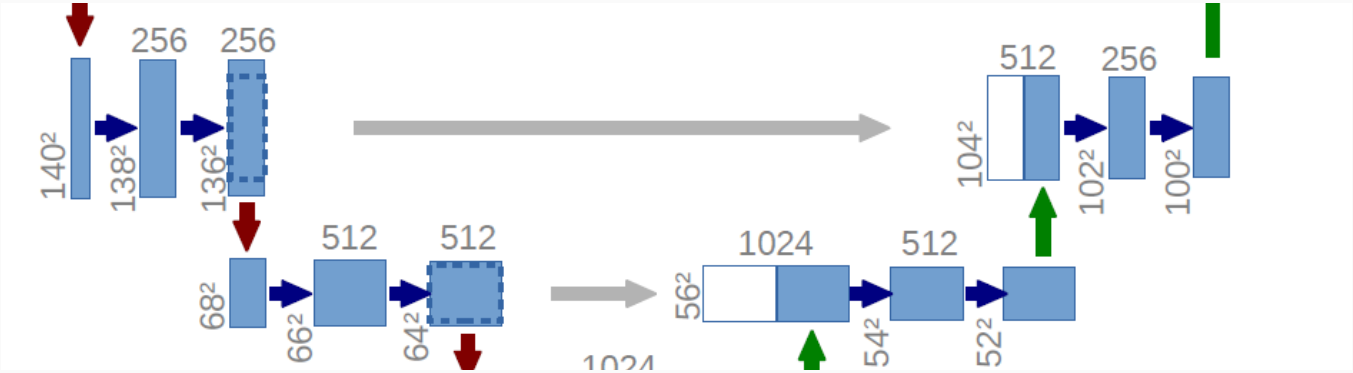


[2]

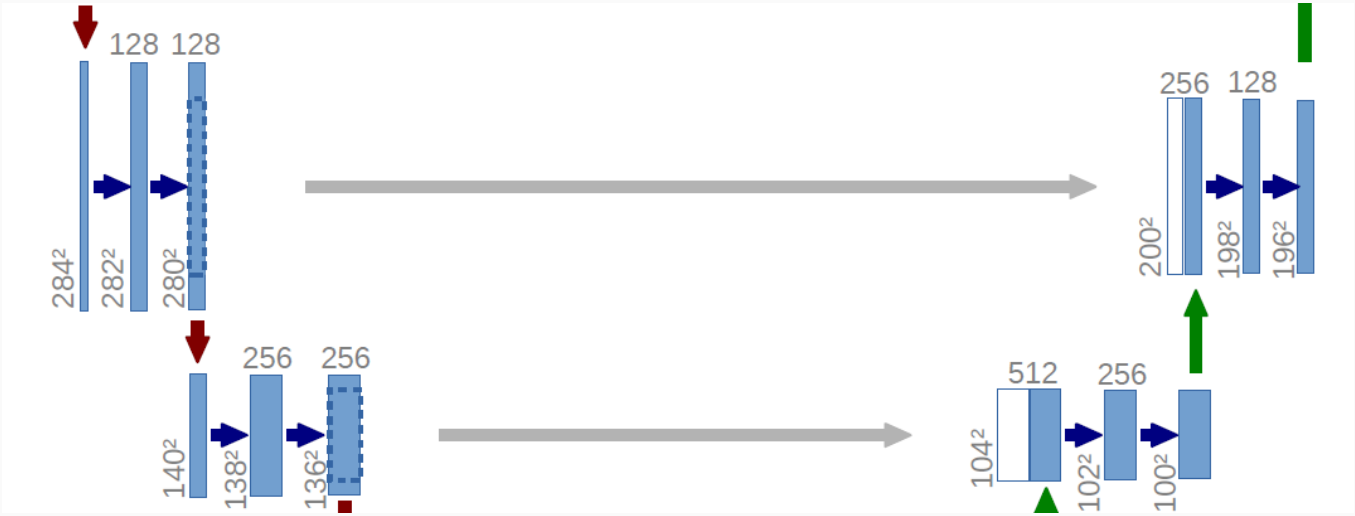
U-Net Architecture (Expanding)



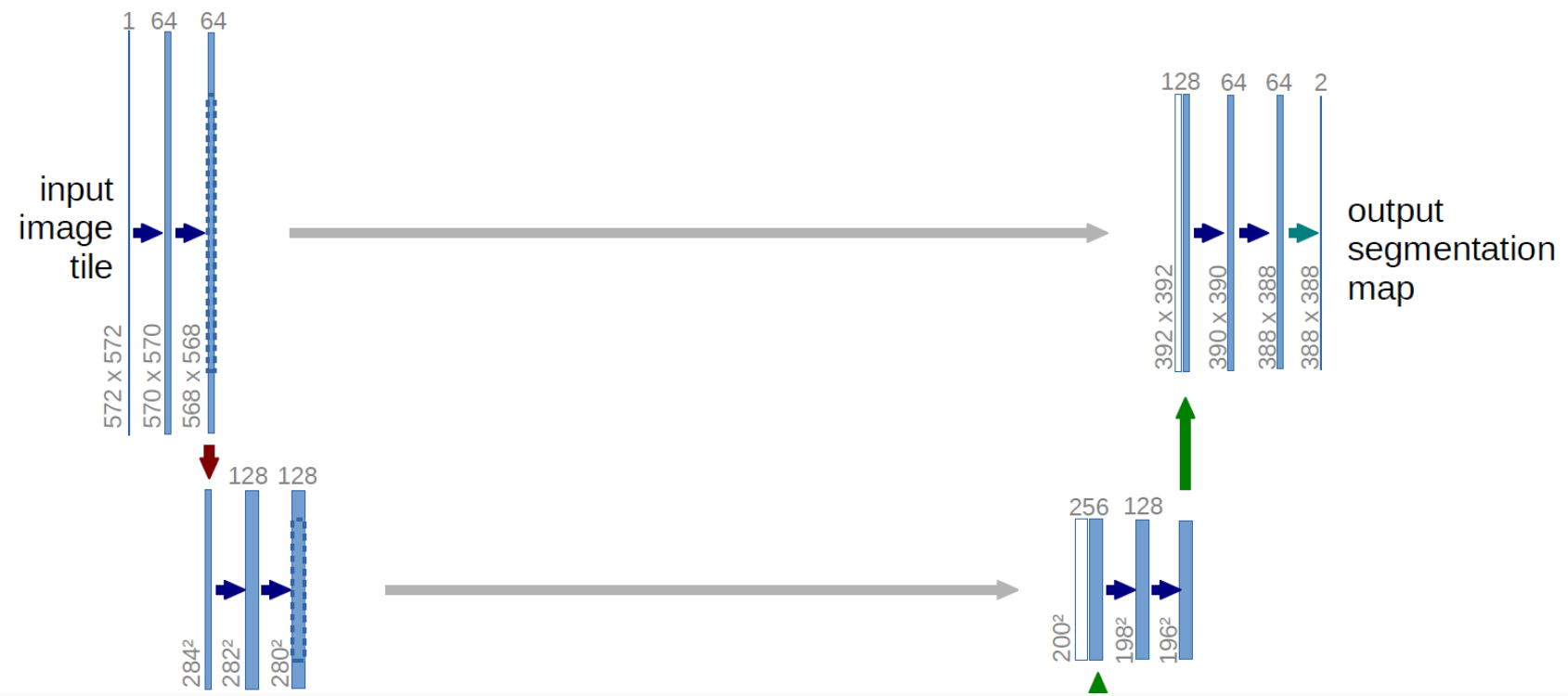
U-Net Architecture (Expanding)



U-Net Architecture (Expanding)

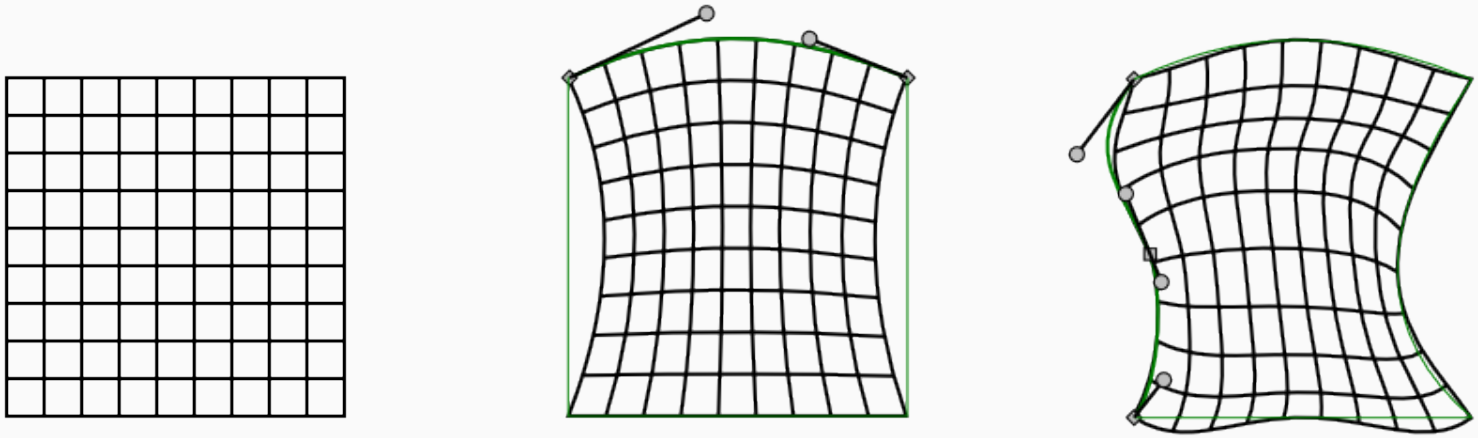


U-Net Architecture (Expanding)



Overcoming Small Dataset

Elastic Deformations



Python implementation or Keras

Touching Objects of the same class

Applying a Weighted Loss to Boundary Pixels

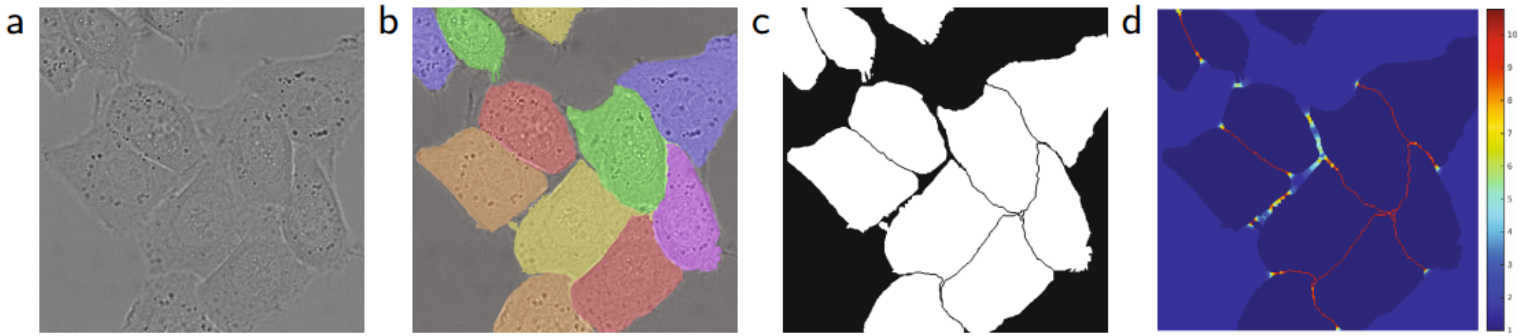


Fig. 3. HeLa cells on glass recorded with DIC (differential interference contrast) microscopy. (**a**) raw image. (**b**) overlay with ground truth segmentation. Different colors indicate different instances of the HeLa cells. (**c**) generated segmentation mask (white: foreground, black: background). (**d**) map with a pixel-wise loss weight to force the network to learn the border pixels.

Morphological Operations

Weight Map

$$w(\mathbf{x}) = w_c(\mathbf{x}) + w_0 \cdot \exp\left(-\frac{(d_1(\mathbf{x}) + d_2(\mathbf{x}))^2}{2\sigma^2}\right)$$

- $w_c(\mathbf{x})$ is a weight map to balance class frequencies
- d_1 denotes the distance to the border of the nearest cell
- d_2 denotes the distance to the border of the second nearest cell
- set $w_0 = 10$ and $\sigma = 5$ pixels

References

Ignacio Arganda-Carreras et al. “Crowdsourcing the creation of image segmentation algorithms for connectomics”. In: *Frontiers in Neuroanatomy* 9 (2015). ISSN: 1662-5129. DOI: 10.3389/fnana.2015.00142. URL: https://www.frontiersin.org/articles/10.3389/fnana.2015.00142/full.

Olaf Ronneberger, Philipp Fischer, and Thomas Brox. “U-Net: Convolutional Networks for Biomedical Image Segmentation”. In: *Medical Image Computing and Computer-Assisted Intervention – MICCAI 2015*. Lecture Notes in Computer Science. Springer, Cham, Oct. 2015, pp. 234–241. ISBN: 978-3-319-24573-7. DOI: 10.1007/978-3-319-24574-4_28. URL: https://link.springer.com/chapter/10.1007%2F978-3-319-24574-4_28.

Vladimír Ulman et al. “An objective comparison of cell-tracking algorithms”. In: *Nature Methods* 14.12 (Dec. 2017), p. 1141. ISSN: 1548-7105. DOI: 10.1038/nmeth.4473.