Computing Methods for Experimental Physics and Data Analysis

Data Analysis in Medical Physics

Deep Learning exercises: Image segmentation with CAE

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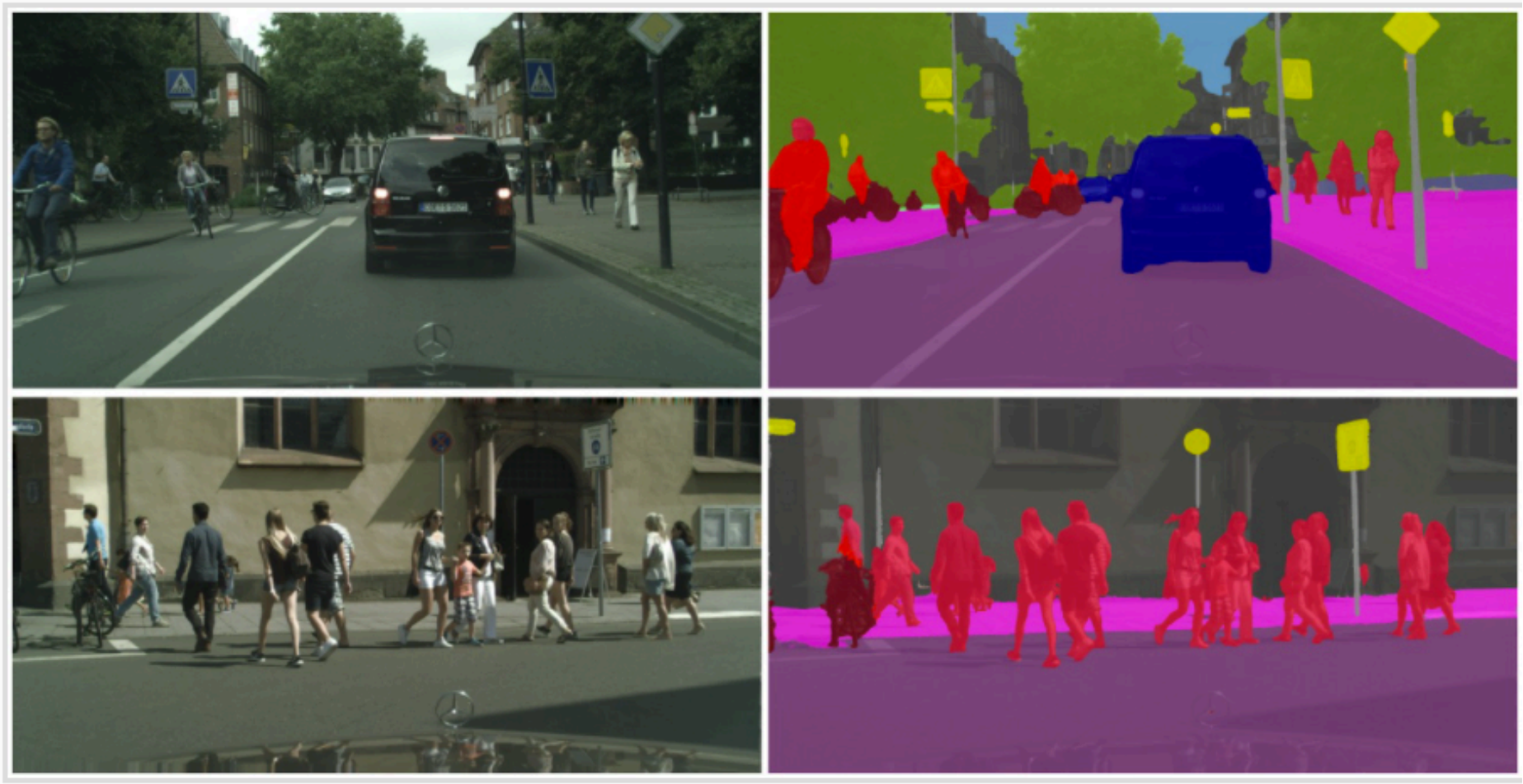
Semantic segmentation



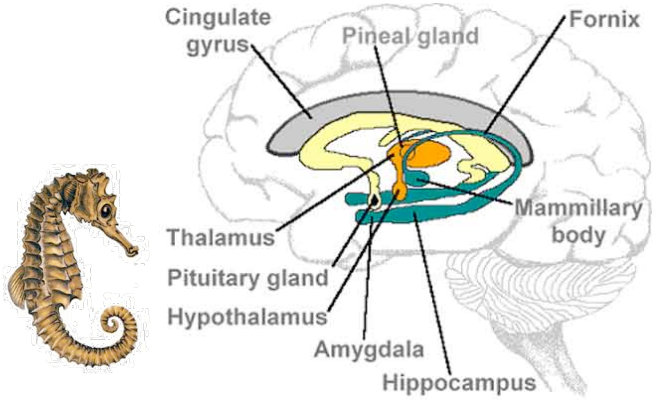
Semantic segmentation is the process of classifying each pixel belonging to a particular label.
It does not distinguish different instances of the same object.

https://vladlen.info/publications/feature-space-optimization-for-semantic-video-segmentation/

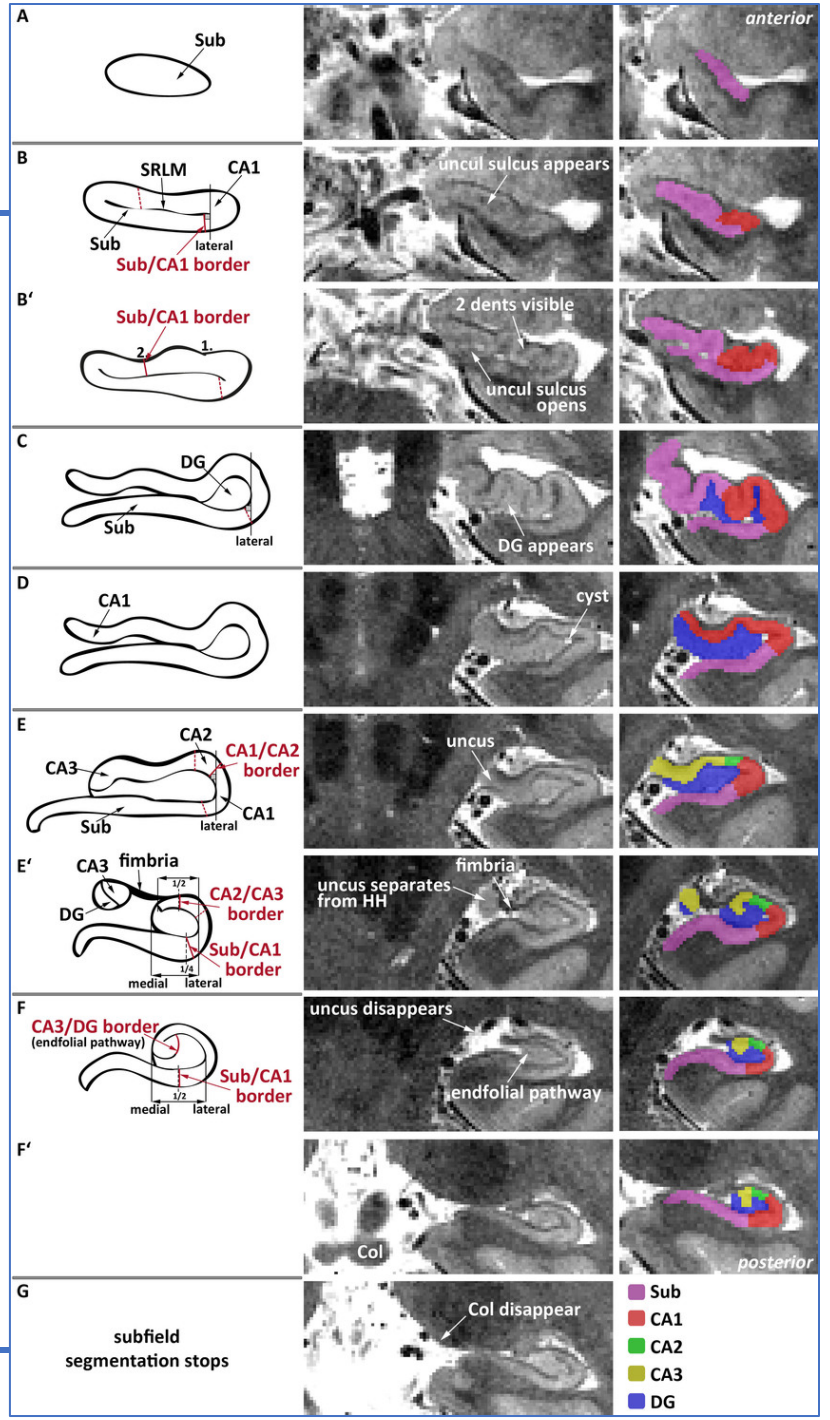
Medica image segmentation

- Image segmentation: the image is partitioned into its parts or regions (segments)
- Segmentation of tissues, organs, lesions or other **regions of interest (ROIs)** out of a medical image is often a useful step to extract meaningful information related to shape or texture of the object of interest

For example, in the study of Alzheimer's Disease (AD), the hippocampus is one of the first regions of the brain to suffer damage; memory loss and disorientation are included among the early AD symptoms.

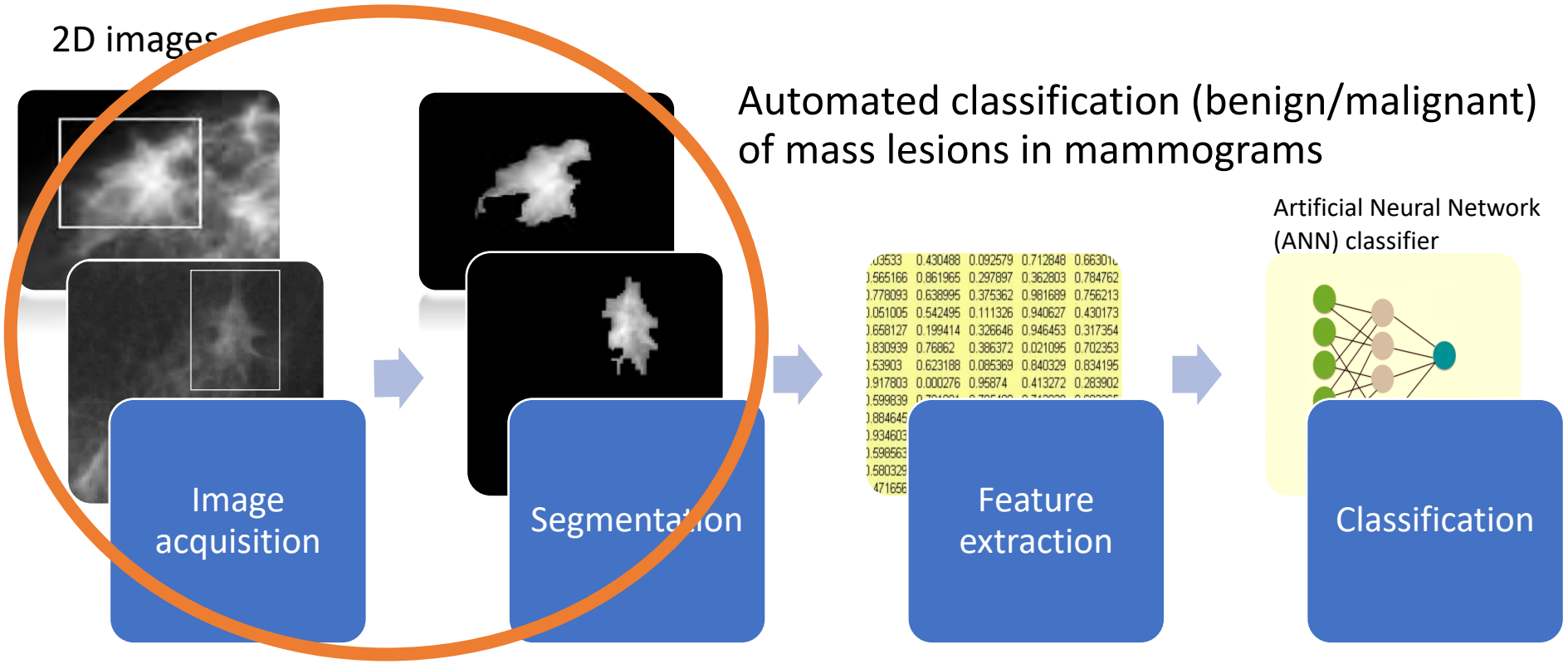


D. Berron et al., A protocol for manual segmentation of medial temporal lobe subregions in 7 Tesla MRI, NeuroImage: Clinical 15(C) 2017



Typical image analysis pipeline for assisted diagnosis

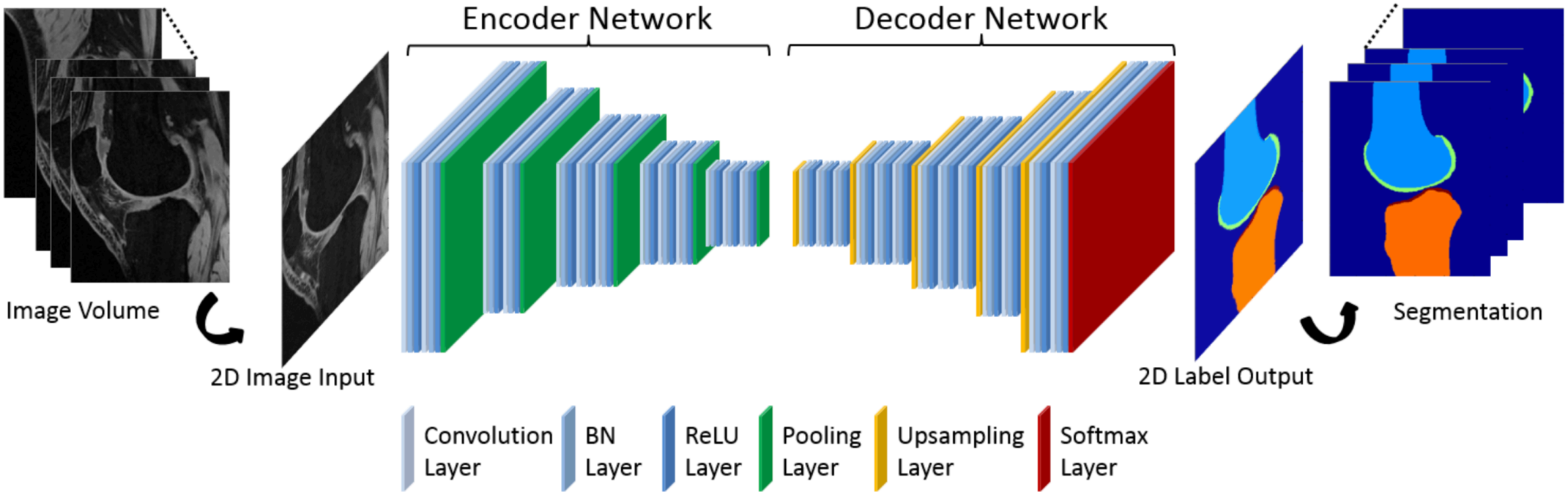
Example: 1) Object segmentation; 2) Hand-crafted feature extraction; 3) Machine Learning classification



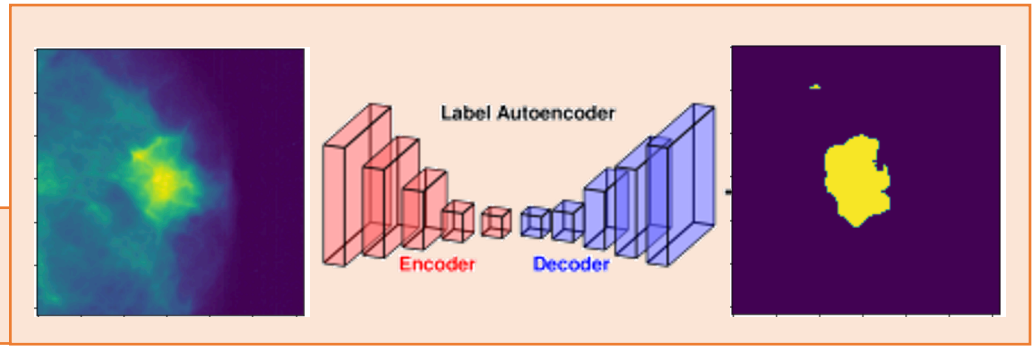
[P Delogu, ME Fantacci, P Kasae, A Retico, Computers in Biology and Medicine 37 (2007) 1479 – 1491]

See demo code: mass_segment.m; Data available on https://pandora.infn.it/public/cmepda/DATASETS and on https://drive.google.com/drive/folders/1YqK7ZkM-P2IrqfD7Pj-SCmjz-GWd_1-Y

Convolutional Auto-Encoders for image segmentation



Liu et al, Deep Convolutional Auto-Encoder and 3D Deformable Approach for Tissue Segmentation in Magnetic Resonance Imaging, Proc. Intl. Soc. Mag. Reson. Med. 25, 2017

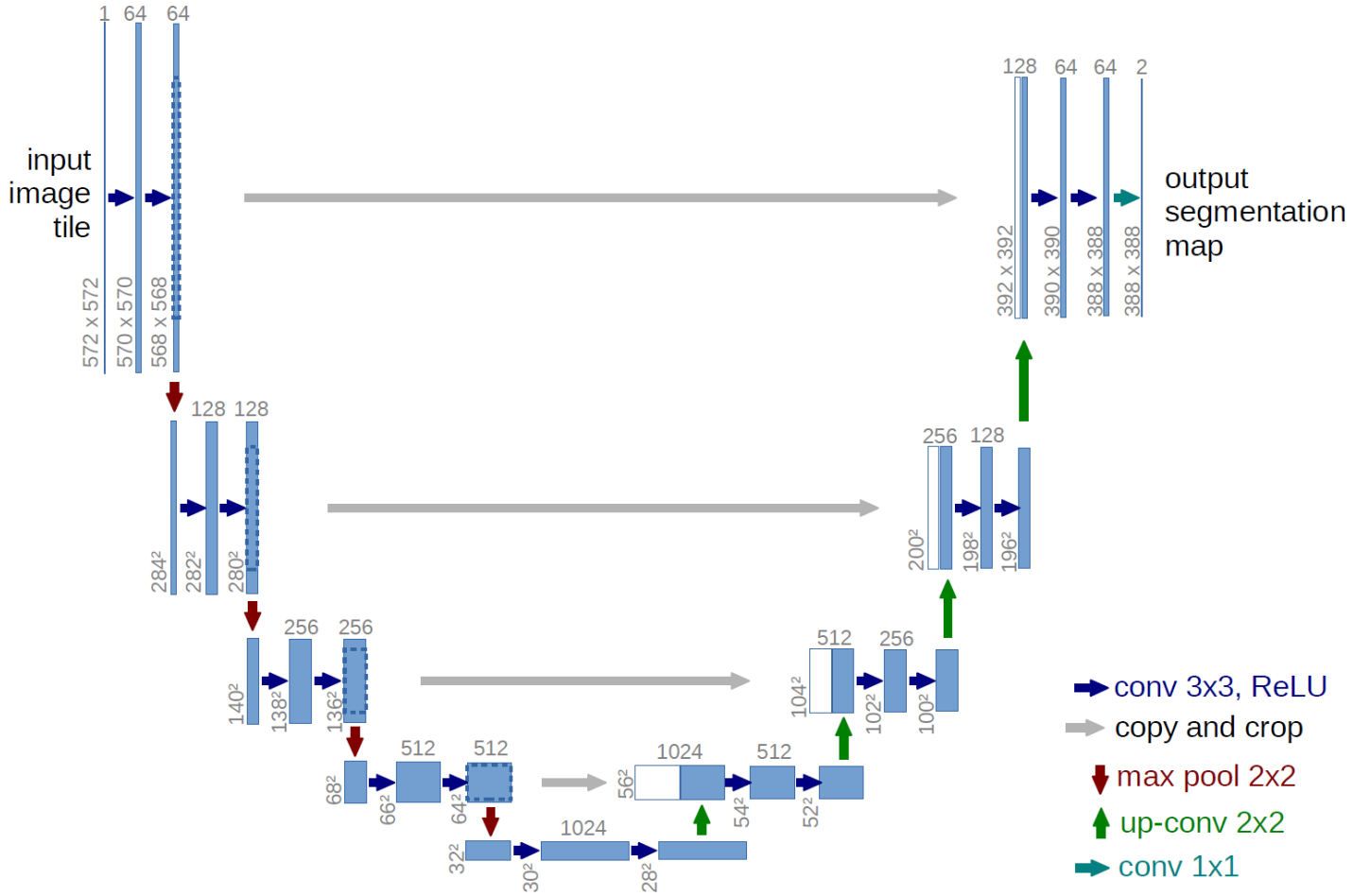


See L12_code/CAE_semantic_segmentation.ipynb on https://github.com/retico/cmepda_medphys/

U-net

U-Net: Convolutional Networks for Biomedical Image Segmentation
Olaf Ronneberger, Philipp Fischer, Thomas Brox
Medical Image Computing and Computer-Assisted Intervention (MICCAI), Springer, LNCS, Vol.9351: 234--241, 2015, available at arXiv:1505.04597

Winner of [ISBI Challenge: Segmentation of neuronal structures in EM stacks]



https://lmb.informatik.uni-freiburg.de/people/ronneber/u-net/

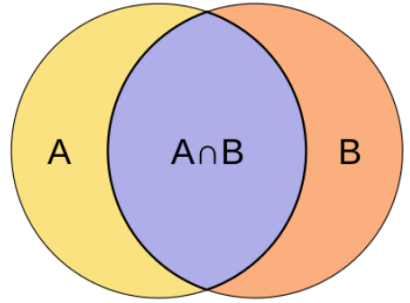
Challenges in data collection

- Precise object localization is hard to annotate
- Annotating every pixel is extremely time consuming
- Common solution is to define a segmentation mask:
  - annotate relevant objects (foreground)
  - mark rest as “other” (background)

Segmentation similarity measures

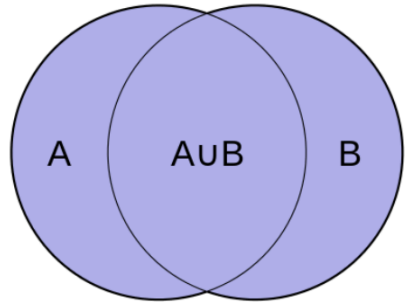
- **Jaccard similarity coefficient: Intersection over Union**

$$J(A,B) = \frac{|A \cap B|}{|A \cup B|} \qquad 0 \leq J(A,B) \leq 1.$$



- **Sørensen-Dice similarity coefficient**

$$DSC = \frac{2|X \cap Y|}{|X| + |Y|}$$



where $|X|$ and $|Y|$ are the cardinalities of the two sets (i.e. the number of elements in each set).
The Sørensen index equals twice the number of elements common to both sets divided by the sum of the number of elements in each set.
When applied to boolean data, using the definition of true positive (TP), false positive (FP), and false negative (FN), it can be written as

$$DSC = \frac{2TP}{2TP + FP + FN}.$$

It is different from Jaccard index which only counts true positives once in both the numerator and denominator.

Useful links

Papers

- Liu et al, Deep Convolutional Auto-Encoder and 3D Deformable Approach for Tissue Segmentation in Magnetic Resonance Imaging, Proc. Intl. Soc. Mag. Reson. Med. 25, 2017
- Vijay Badrinarayanan et. al 2017 “SegNet: A Deep Convolutional Encoder-Decoder Architecture for Image Segmentation” https://arxiv.org/abs/1511.00561
- U-Net: Convolutional Networks for Biomedical Image Segmentation Olaf Ronneberger, Philipp Fischer, Thomas Brox, Medical Image Computing and Computer-Assisted Intervention (MICCAI), Springer, LNCS, Vol.9351: 234--241, 2015, available at arXiv:1505.04597

Blogs

- https://towardsdatascience.com/master-the-coco-dataset-for-semantic-image-segmentation-part-1-of-2-732712631047
- https://neptune.ai/blog/image-segmentation-in-2020

Datasets Blogs

- https://archive.ics.uci.edu/ml/datasets/Image+Segmentation
- https://cocodataset.org/#home
- https://groups.csail.mit.edu/vision/datasets/ADE20K/
- https://www2.eecs.berkeley.edu/Research/Projects/CS/vision/grouping/fg/
- https://medium.com/playment/top-10-open-image-datasets-for-machine-learning-research-93ab9c18bed1

Repos

- https://github.com/Xanthor-Aditya/
- https://lmb.informatik.uni-freiburg.de/people/ronneber/u-net/