Segmentation

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Classification

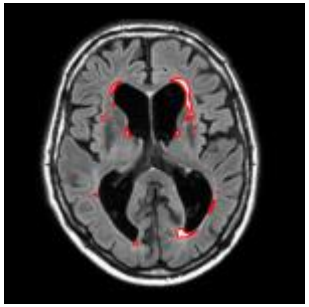
Cat

Segmentation

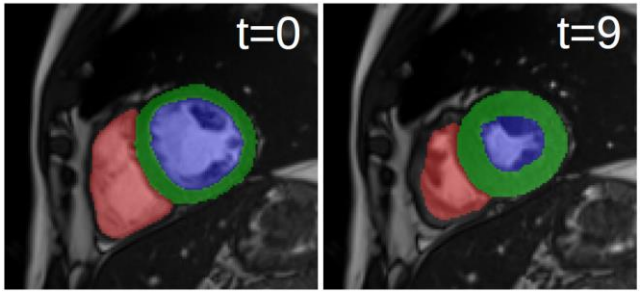
GRASS, CAT,
TREE, SKY

Detection

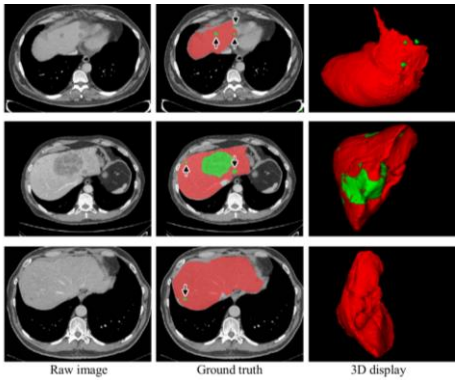
DOG, DOG, CAT



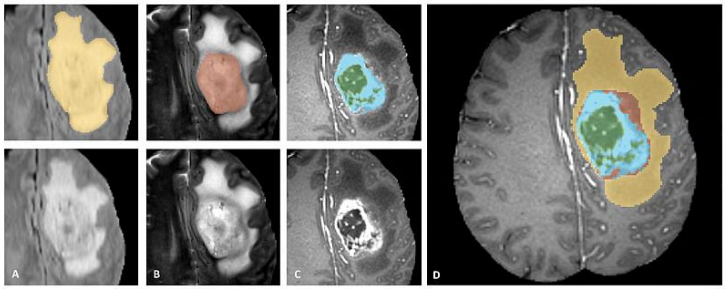
WMH



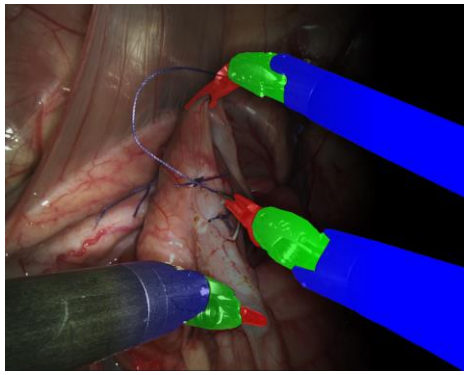
ACDC



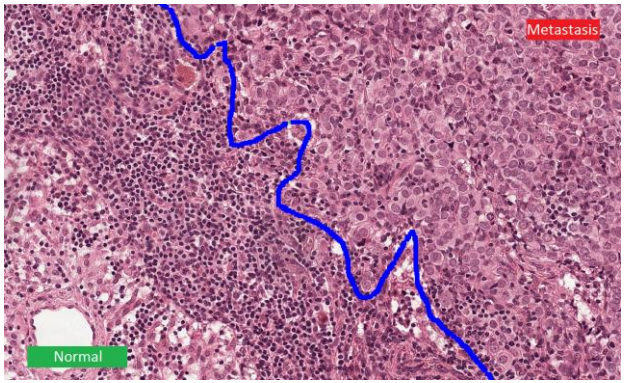
LiTS



BraTS



Endovis



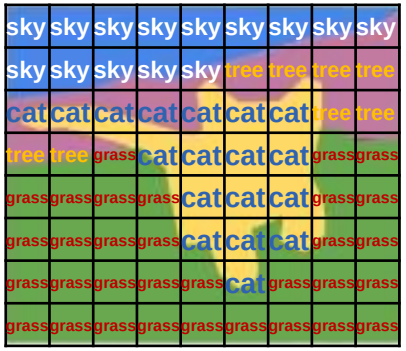
Camelyon

Classification

Cat

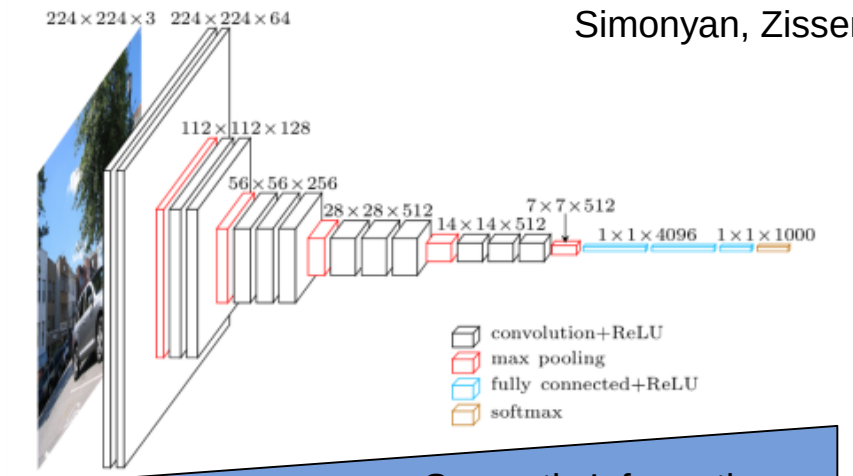
one label per image

Segmentation



one label per pixel

Classification



Simonyan, Zisserman, CVPR, 2014

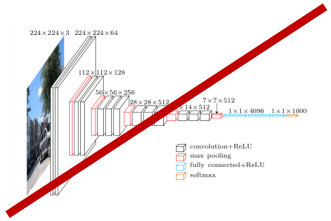
Semantic Information

Spatial Information

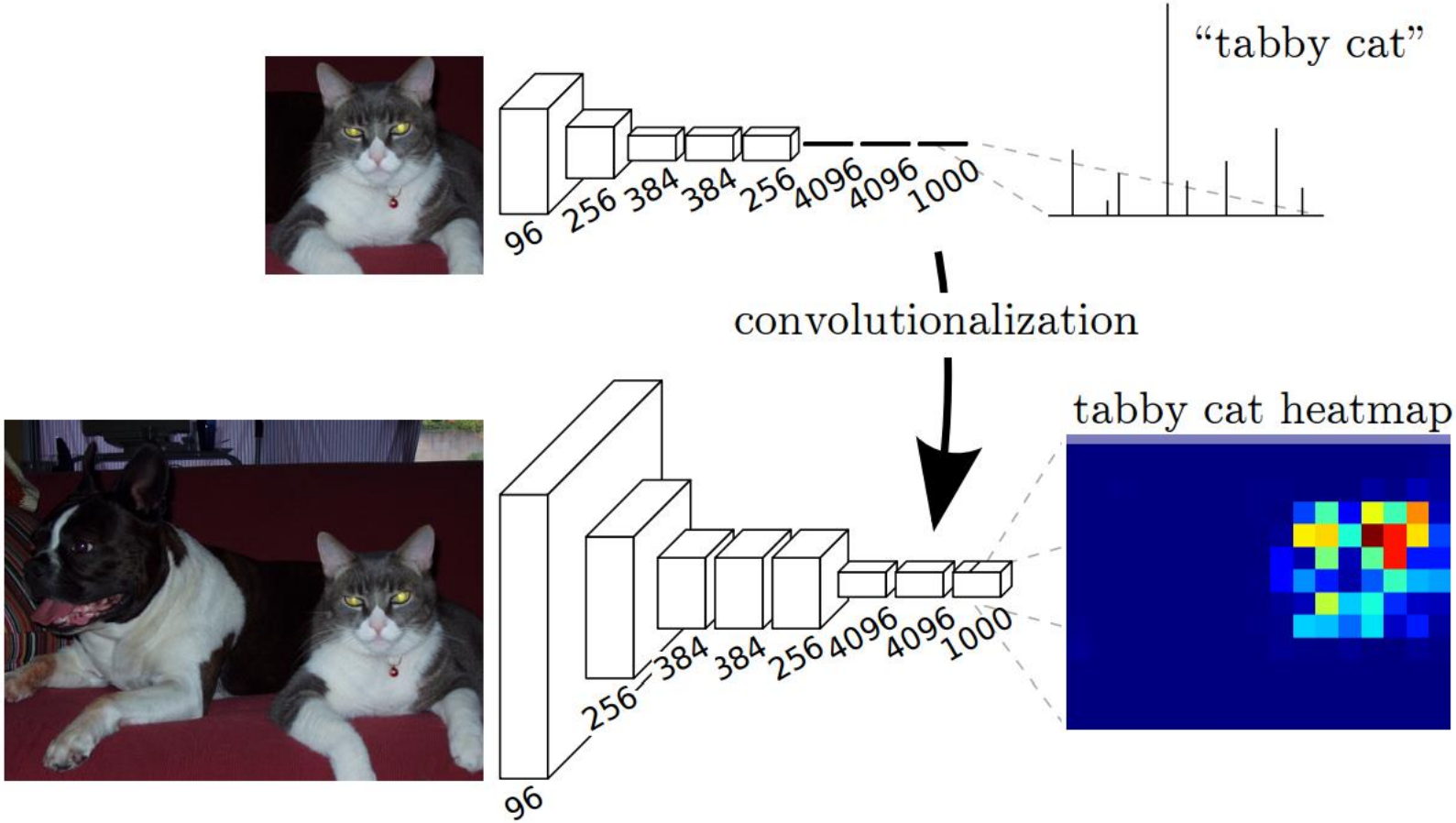
Segmentation

Semantic Information

Spatial Information

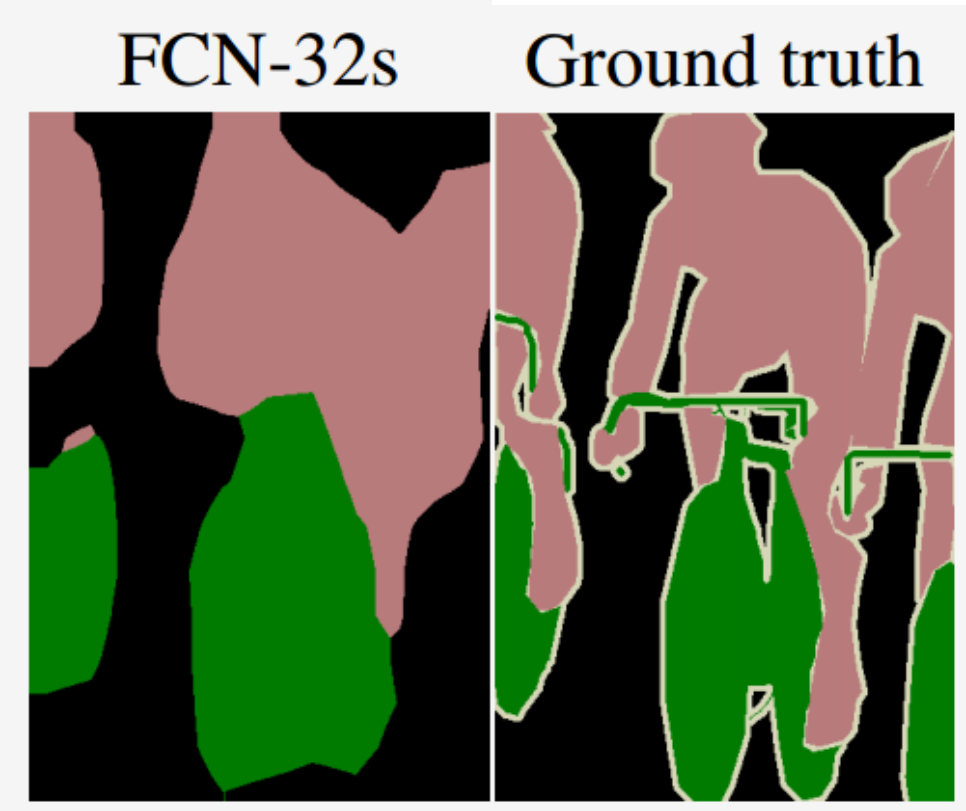


Fully Convolutional Networks for Semantic Segmentation



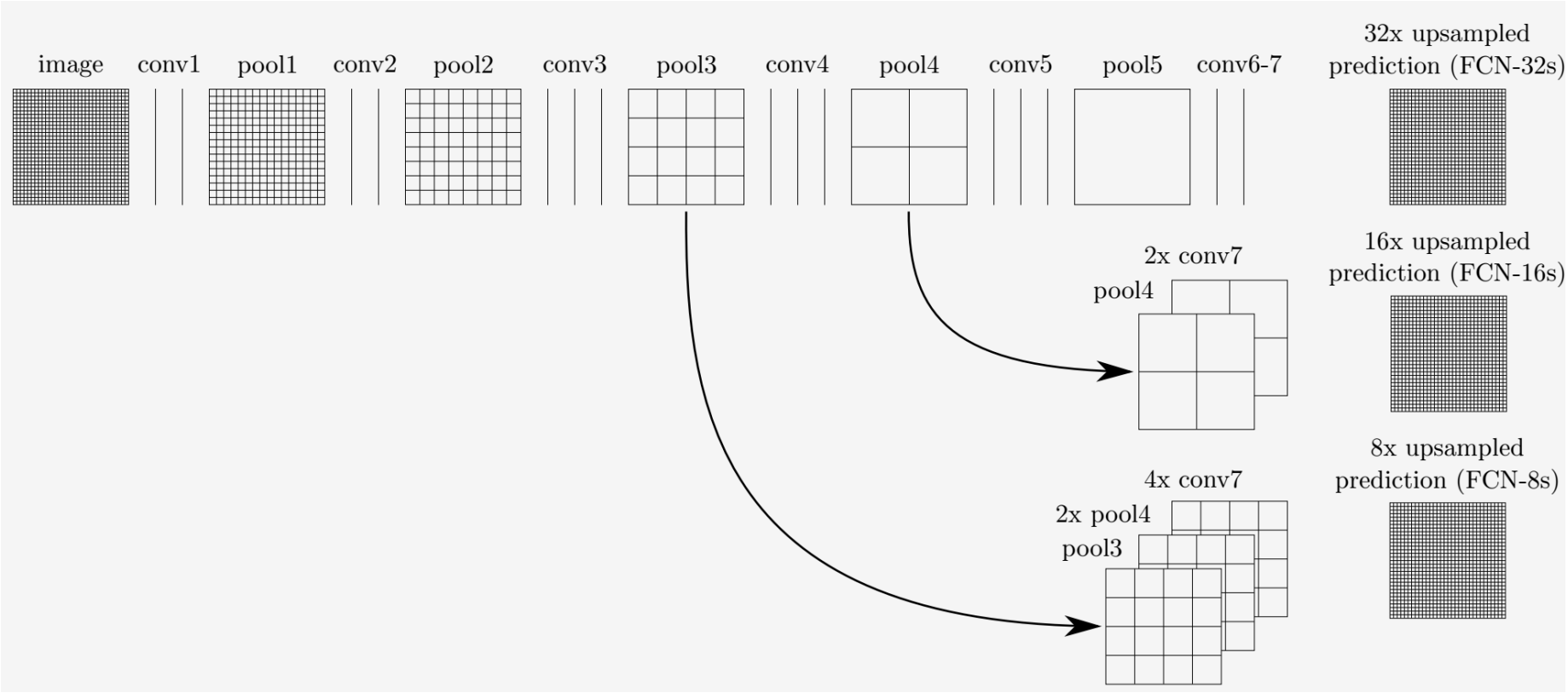
Long et al., CVPR, 2015

Fully Convolutional Networks for Semantic Segmentation



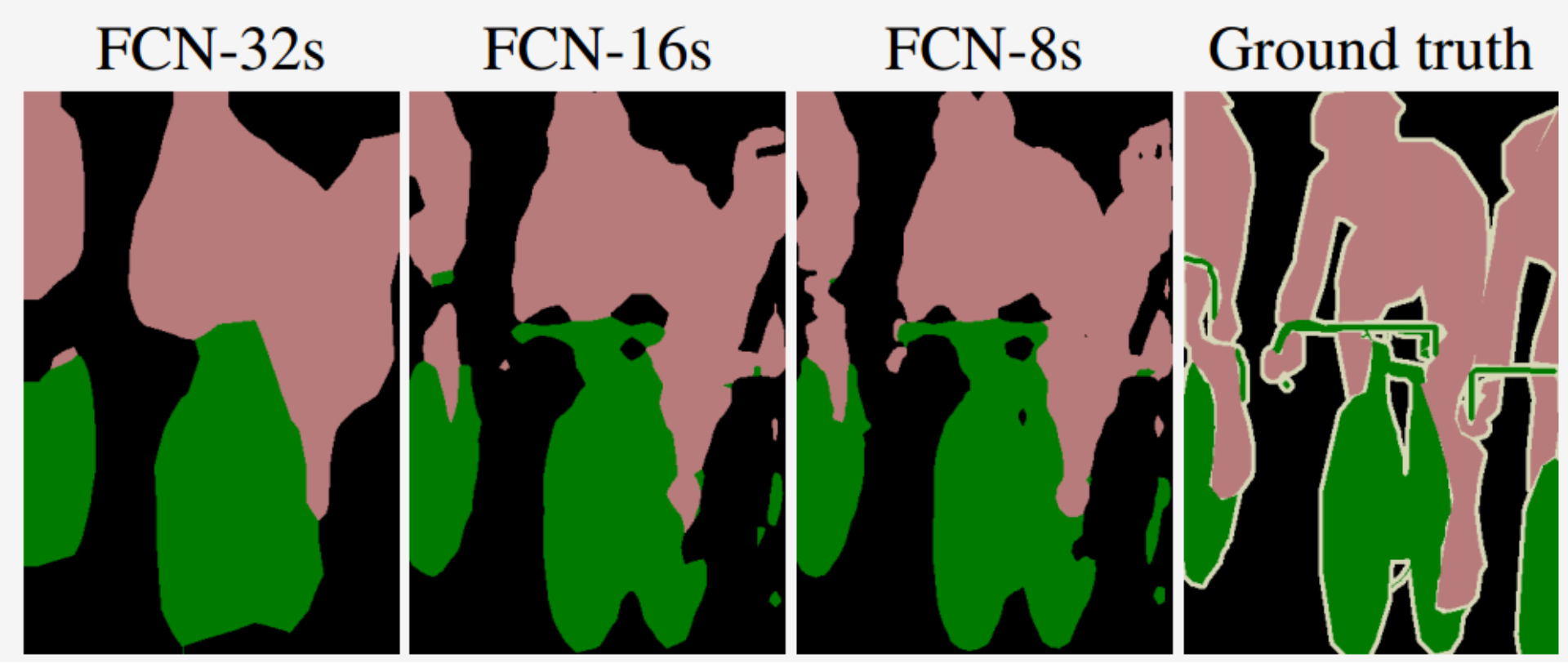
Long et al., CVPR, 2015

Fully Convolutional Networks for Semantic Segmentation



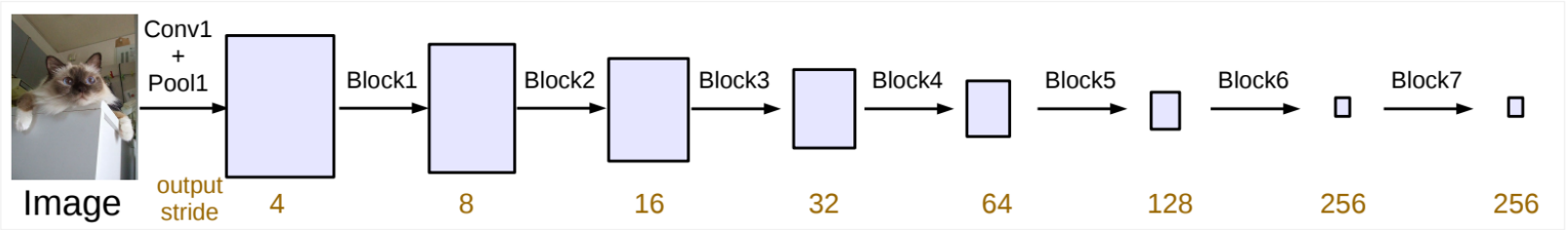
Long et al., CVPR, 2015

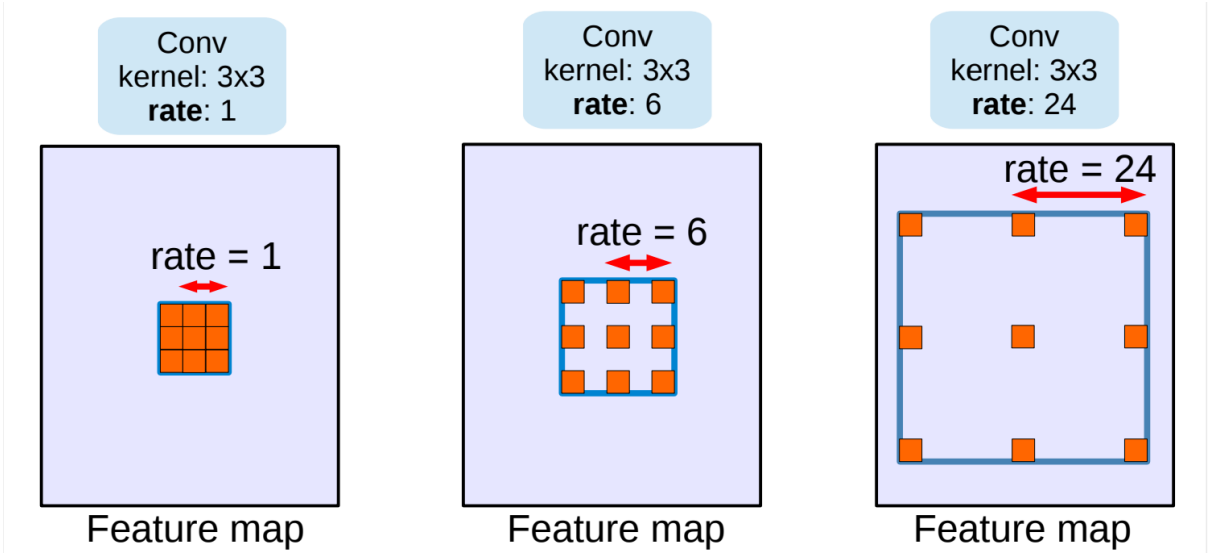
Fully Convolutional Networks for Semantic Segmentation



Long et al., CVPR, 2015

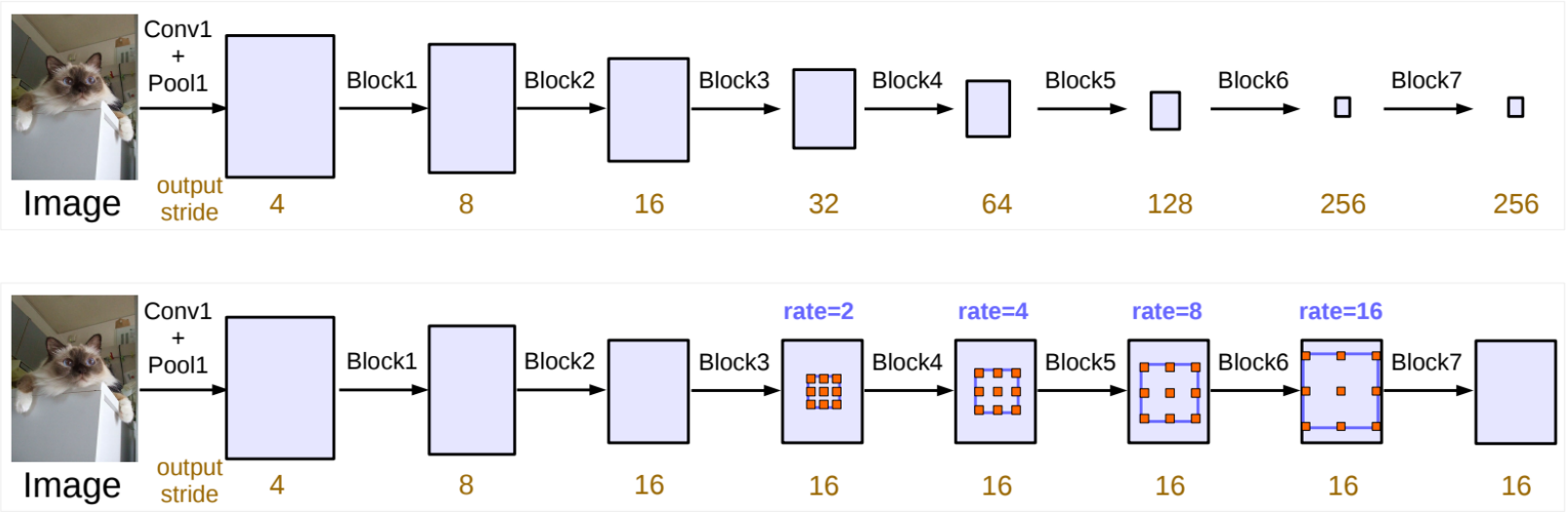
DeepLabv3





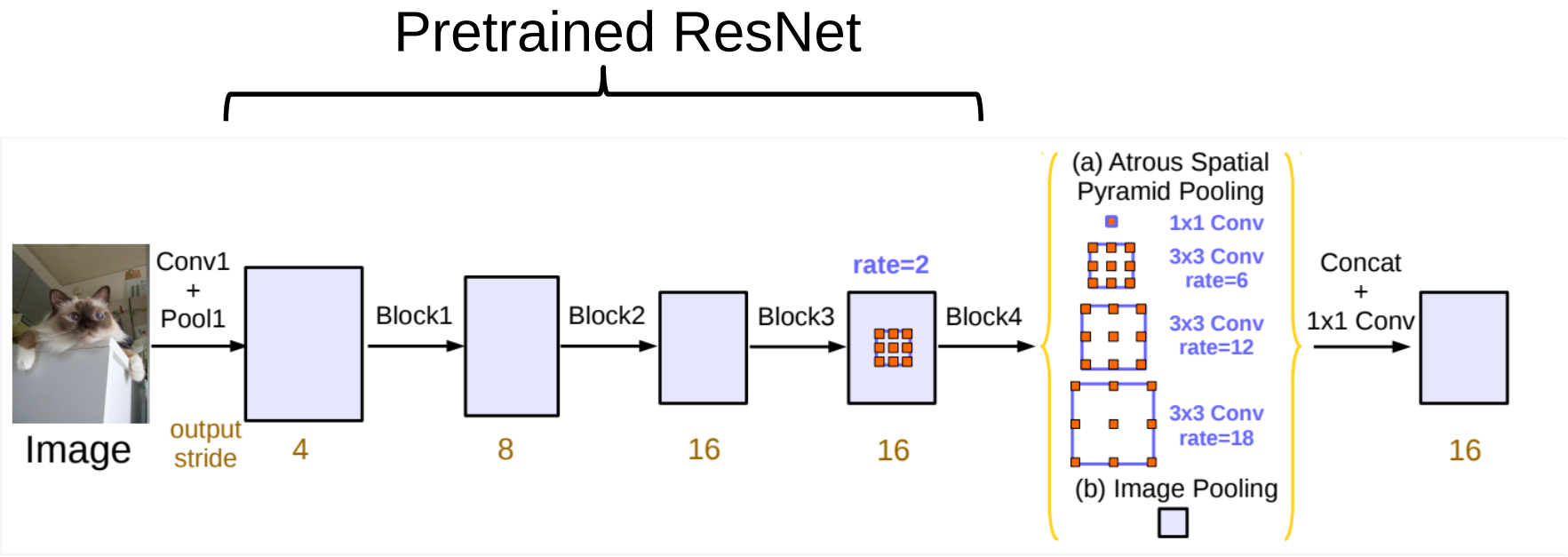
Chen et al., arXiv, 2017

DeepLabv3



Chen et al., arXiv, 2017

DeepLabv3

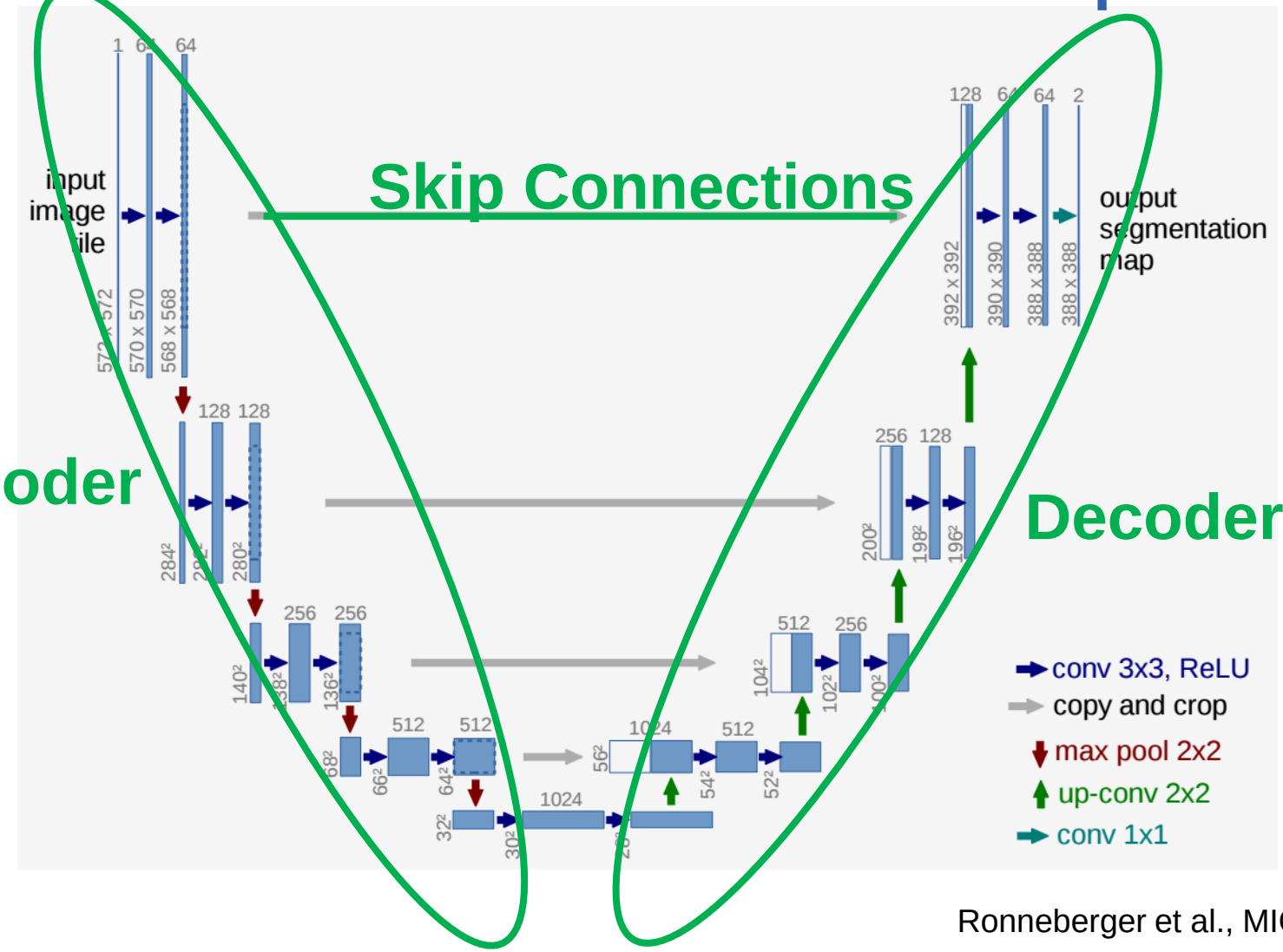


+ Effective utilization of pretrained network
+ Performs very well on semantically demanding tasks
- Output stride 16/8 -> no precise localization
- No pretraining possible for MIC

Chen et al., arXiv, 2017

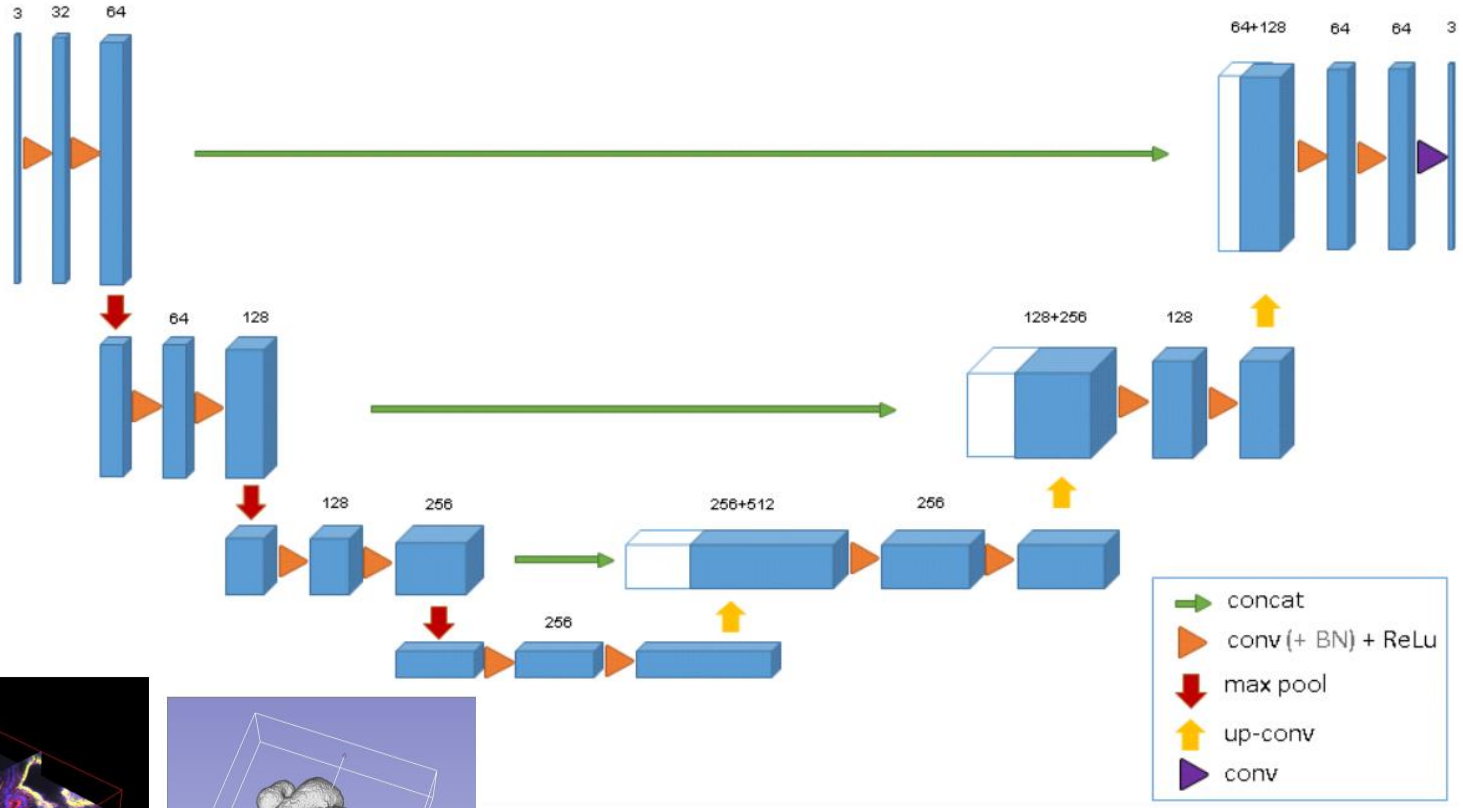
Encoder-Decoder: UNet

output stride 1!

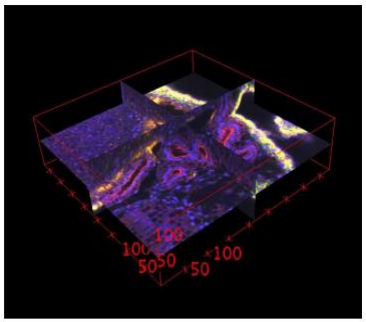


Ronneberger et al., MICCAI, 2015

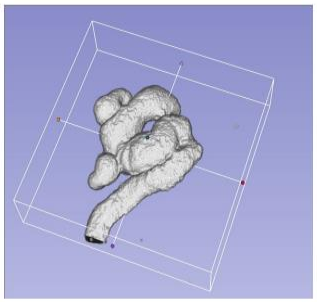
UNet variants: UNet3D



b



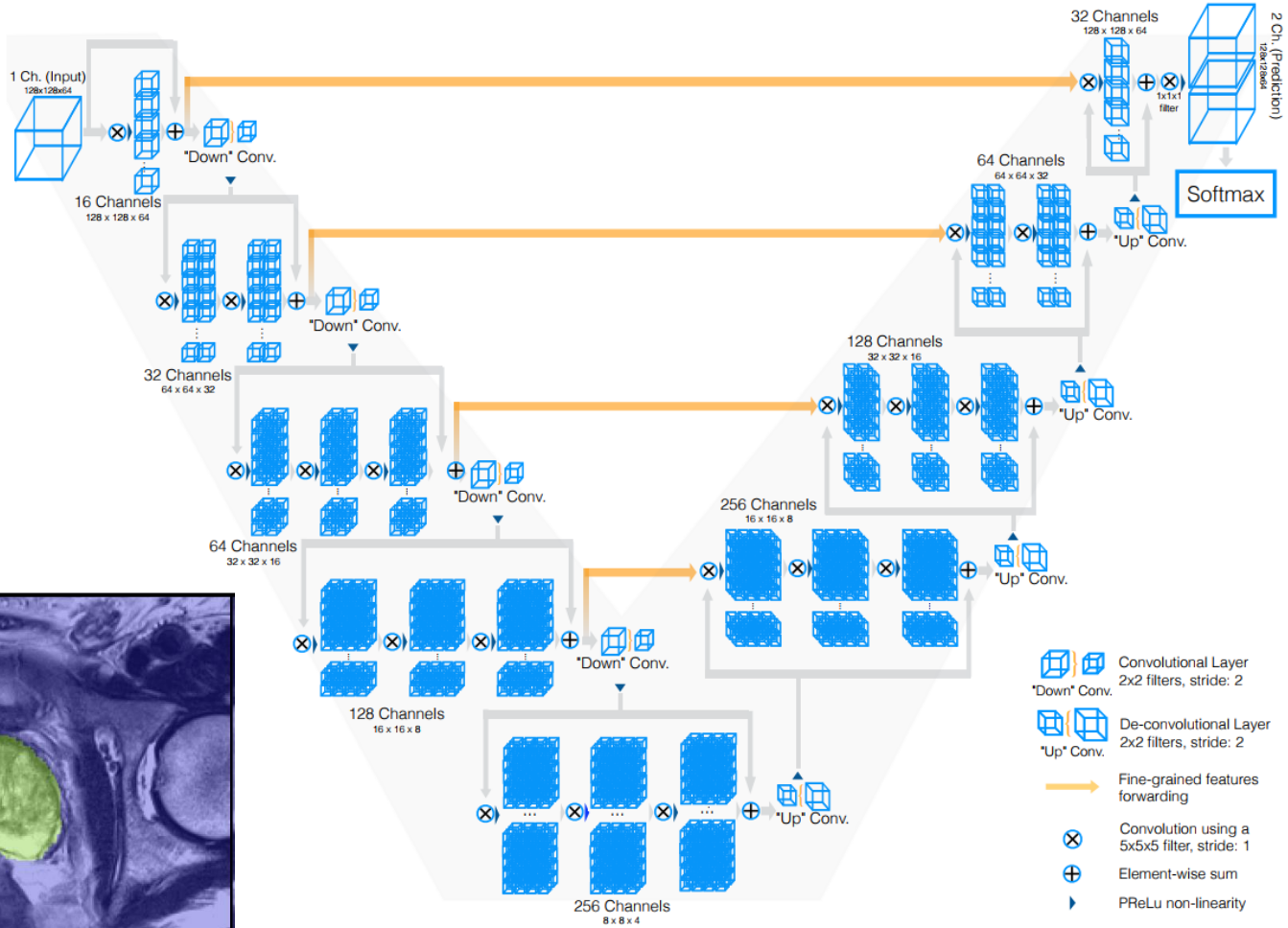
raw image

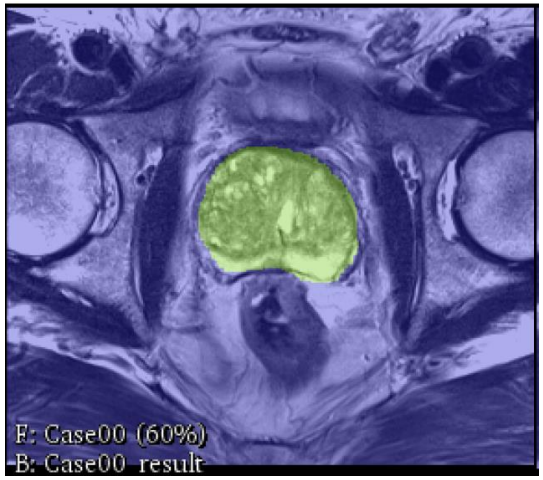


dense segmentation

Cicek et al., MICCAI, 2016

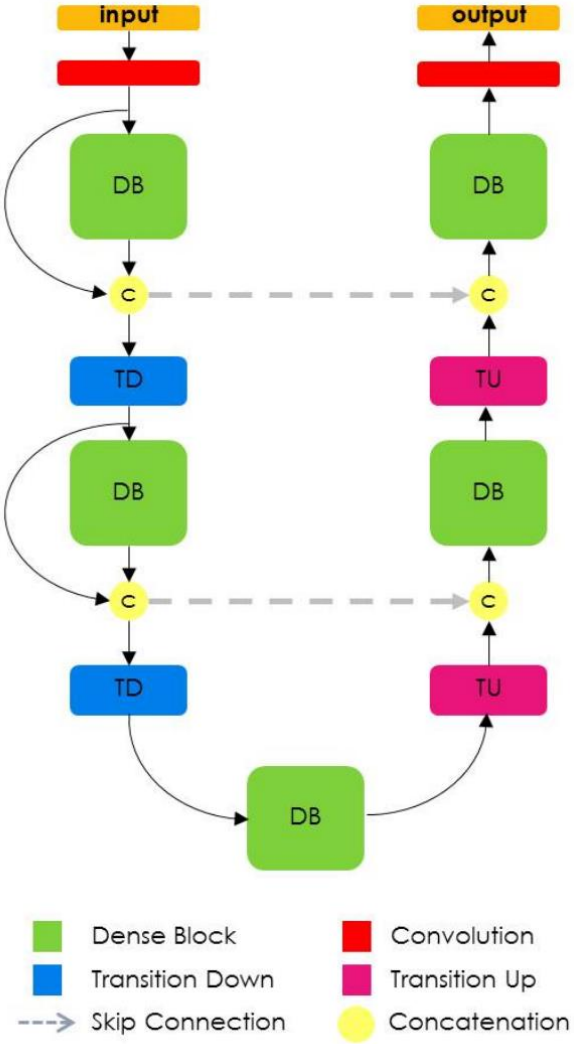
UNet variants: V-Net

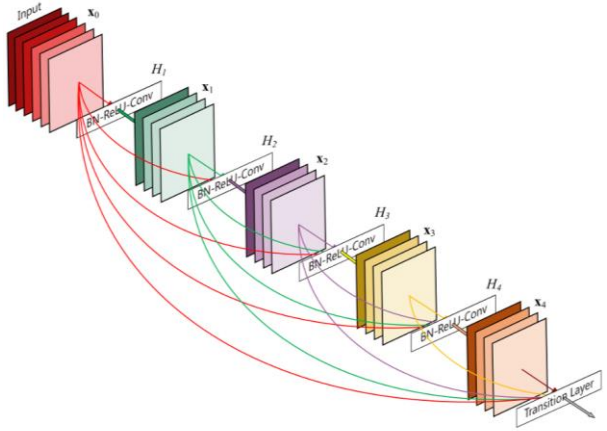




Milletari et al., 3DV, 2016

UNet variants: Dense UNet

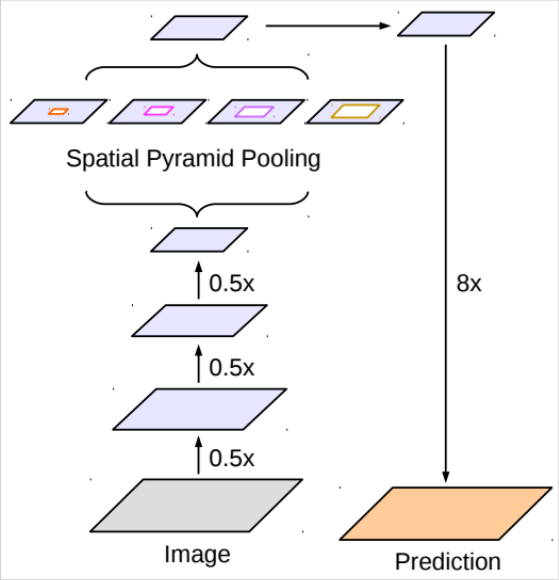




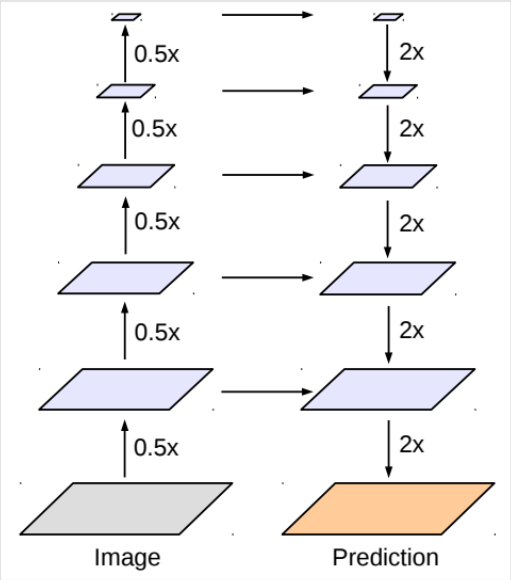
Huang et al., CVPR, 2017

Jegou et al., CVPRW, 2017

DeepLabv3+



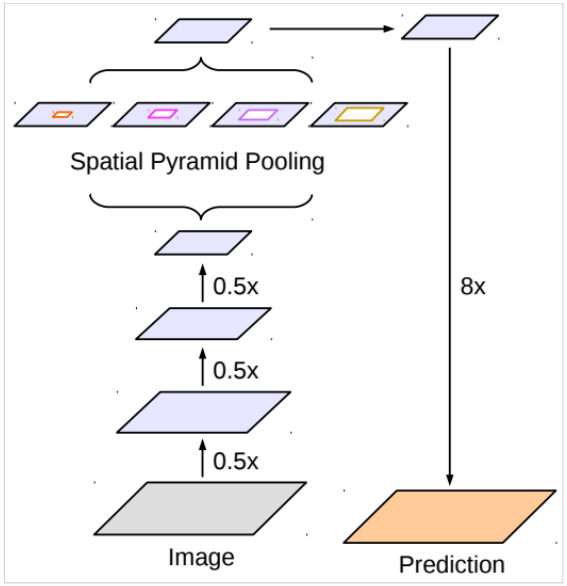
DeepLabv3



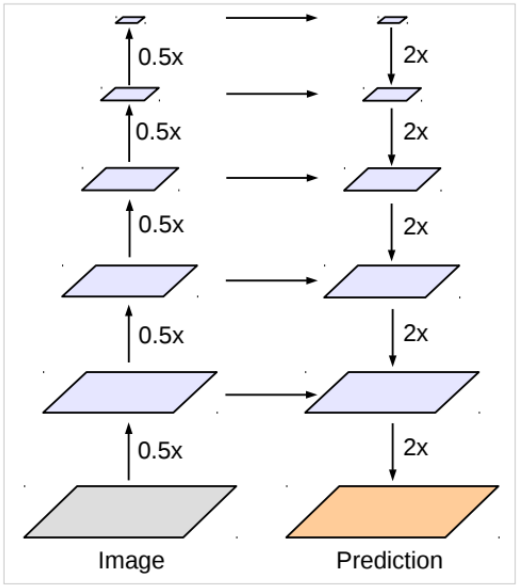
Encoder-Decoder

Chen et al., arXiv, 2018

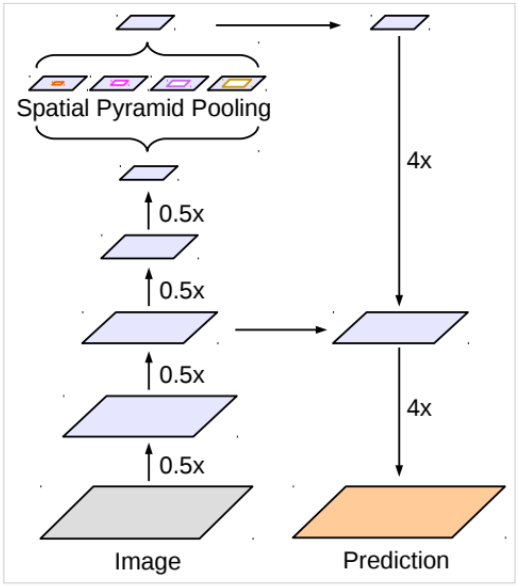
DeepLabv3+



DeepLabv3



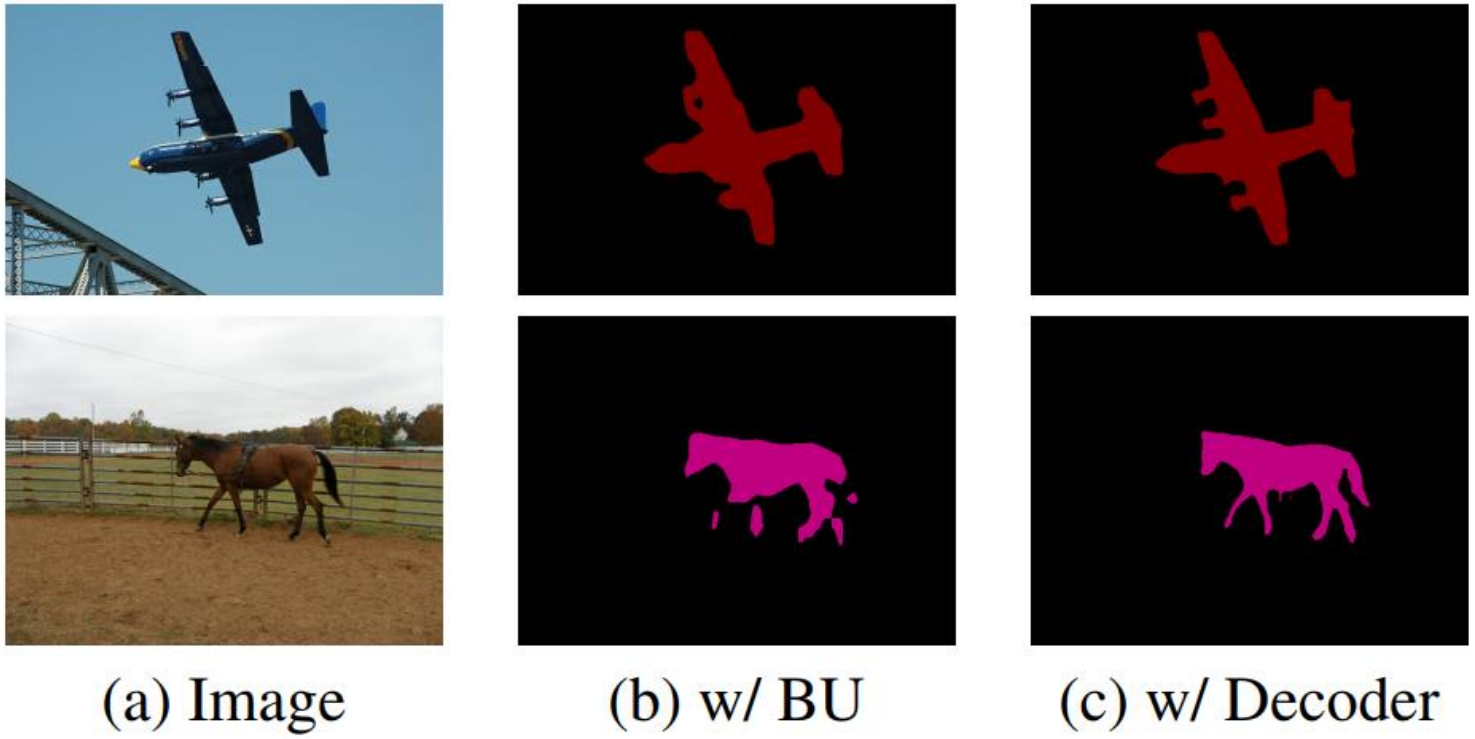
Encoder-Decoder



DeepLabv3+

Chen et al., arXiv, 2018

DeepLabv3+



Chen et al., arXiv, 2018

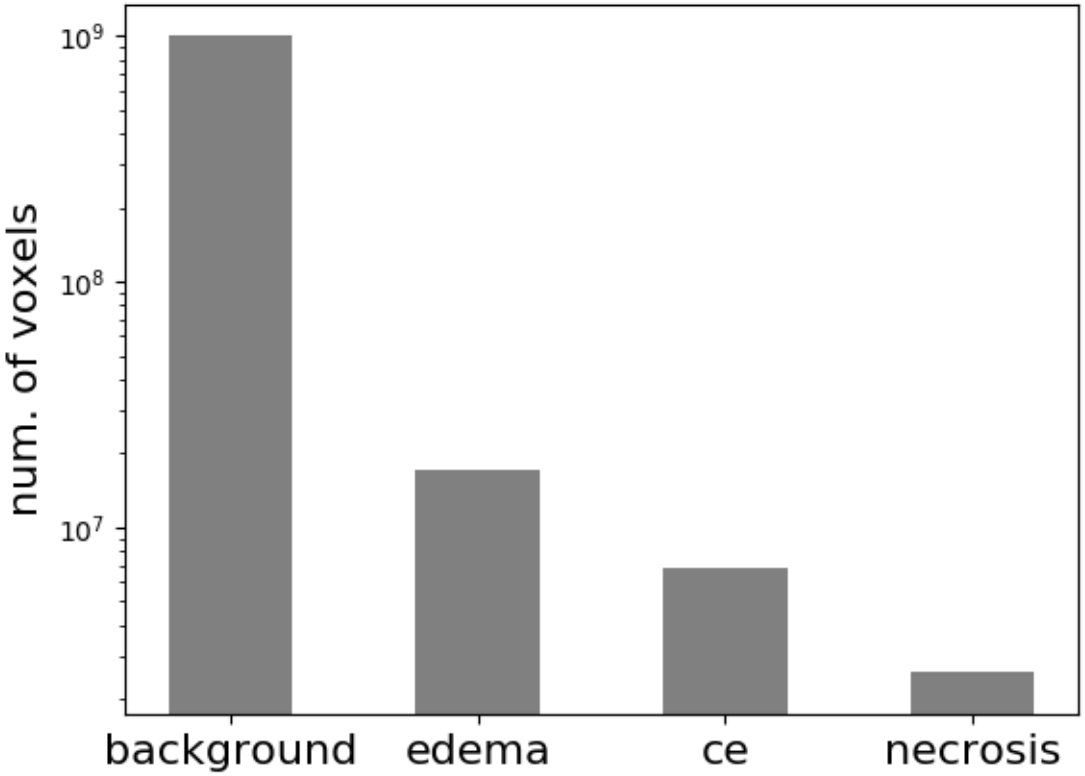
Medical Image Segmentation – Loss functions

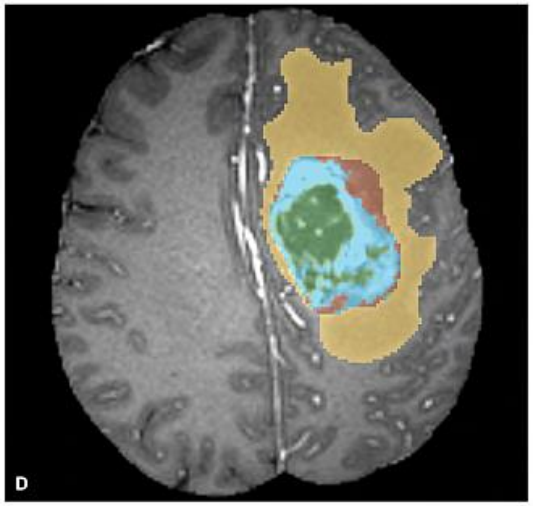
sky	sky	sky	sky	sky	sky	sky	sky	sky
sky	sky	sky	sky	sky	tree	tree	tree	tree
cat	cat	cat	cat	cat	cat	cat	tree	tree
tree	tree	grass	cat	cat	cat	cat	grass	grass
grass	grass	grass	grass	cat	cat	cat	grass	grass
grass	grass	grass	grass	cat	cat	cat	grass	grass
grass	grass	grass	grass	grass	cat	grass	grass	grass
grass	grass	grass	grass	grass	grass	grass	grass	grass

Categorical Crossentropy

$$L_{CE}(p, g) = -\frac{1}{N}\sum_{i \in N}\sum_{k \in K} g_{i,k} \log p_{i,k}$$

Medical Image Segmentation – Loss functions

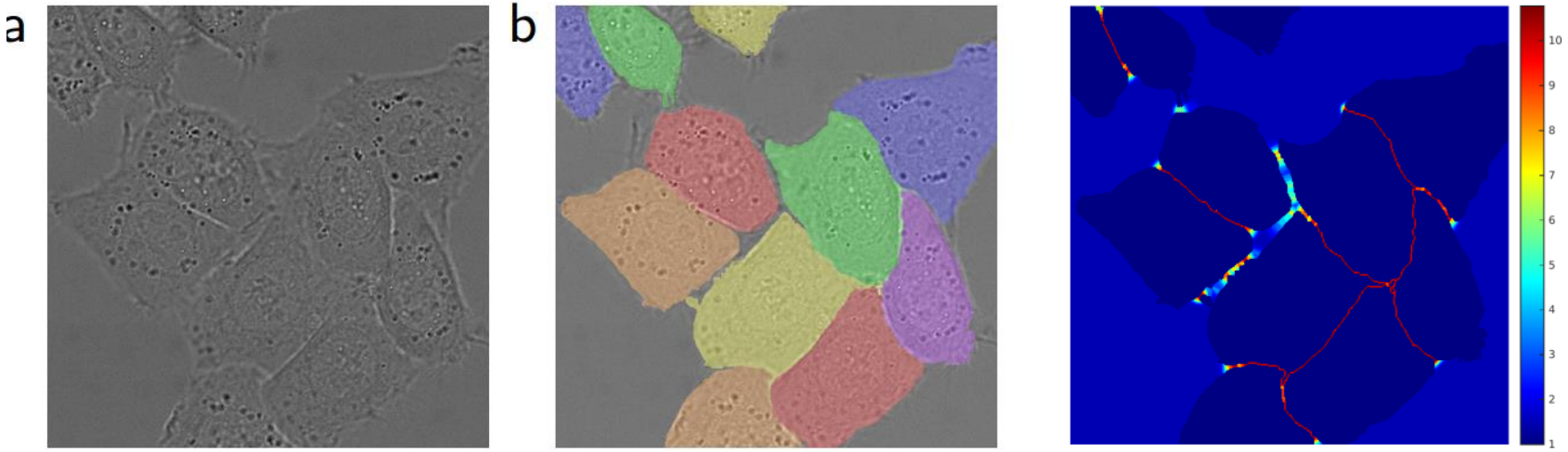




Medical Image Segmentation – Loss functions

Categorical Crossentropy (weighted)

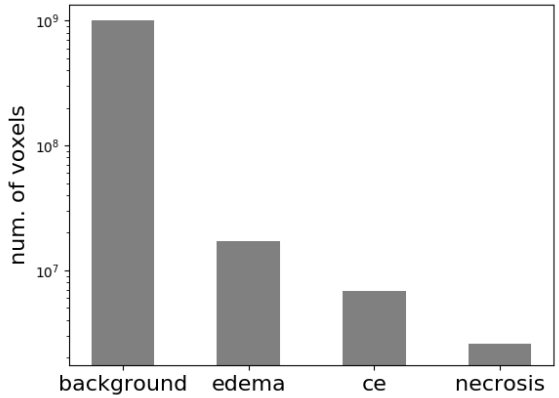
$$L_{WCE}(p, g) = -\frac{1}{N}\sum_{i \in N}\sum_{k \in K} w_i g_{i,k} \log p_{i,k}$$



Ronneberger et al., MICCAI, 2015

Medical Image Segmentation – Loss functions

$$DICE(A,B) = \frac{2\,A \cap B}{|A| + |B|}$$

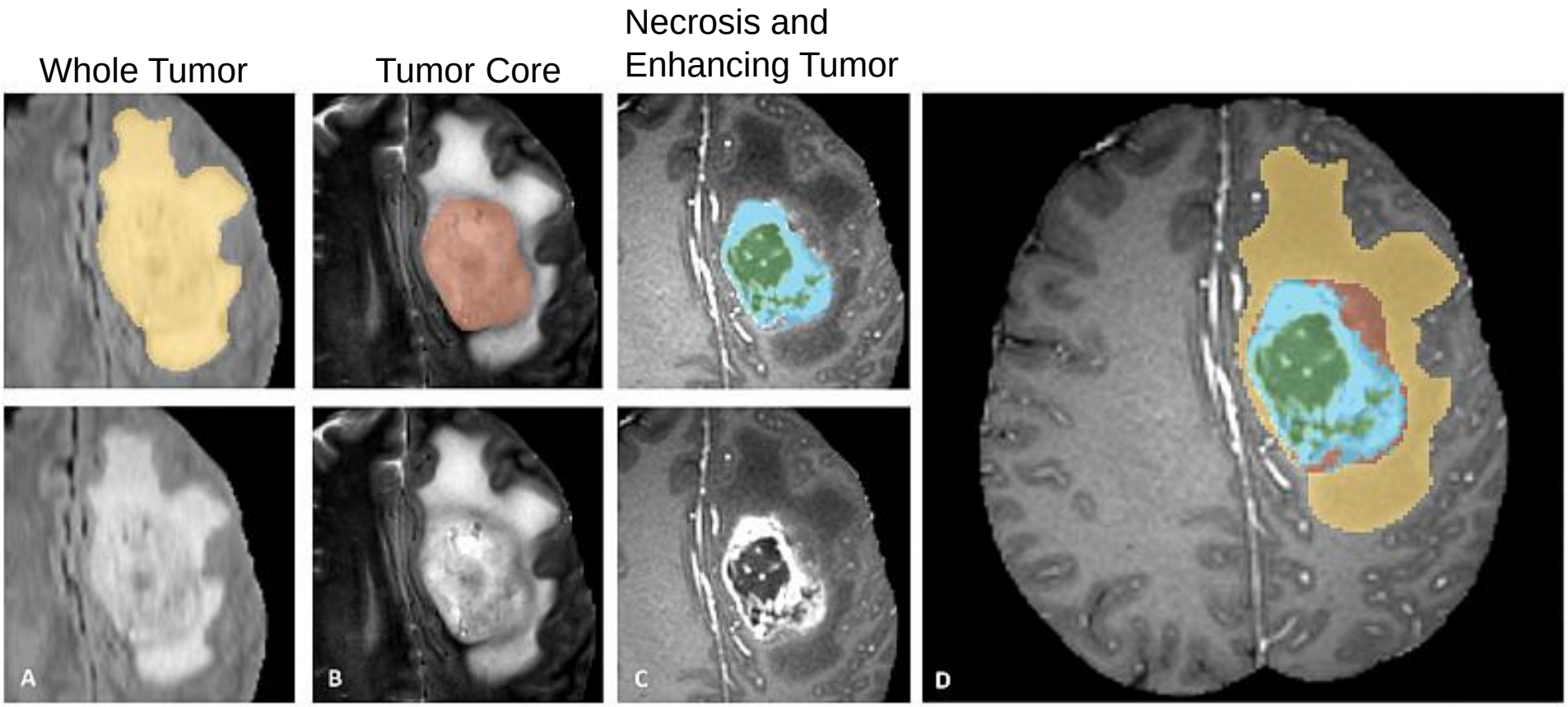


Dice Loss

$$L_{DICE}(p,g) = -\frac{2}{|K|}\sum_{k\in K}\frac{\sum_{i\in N} p_{i,k}\,g_{i,k}}{\sum_{i\in N} p_{i,k} + \sum_{i\in N} g_{i,k}}$$

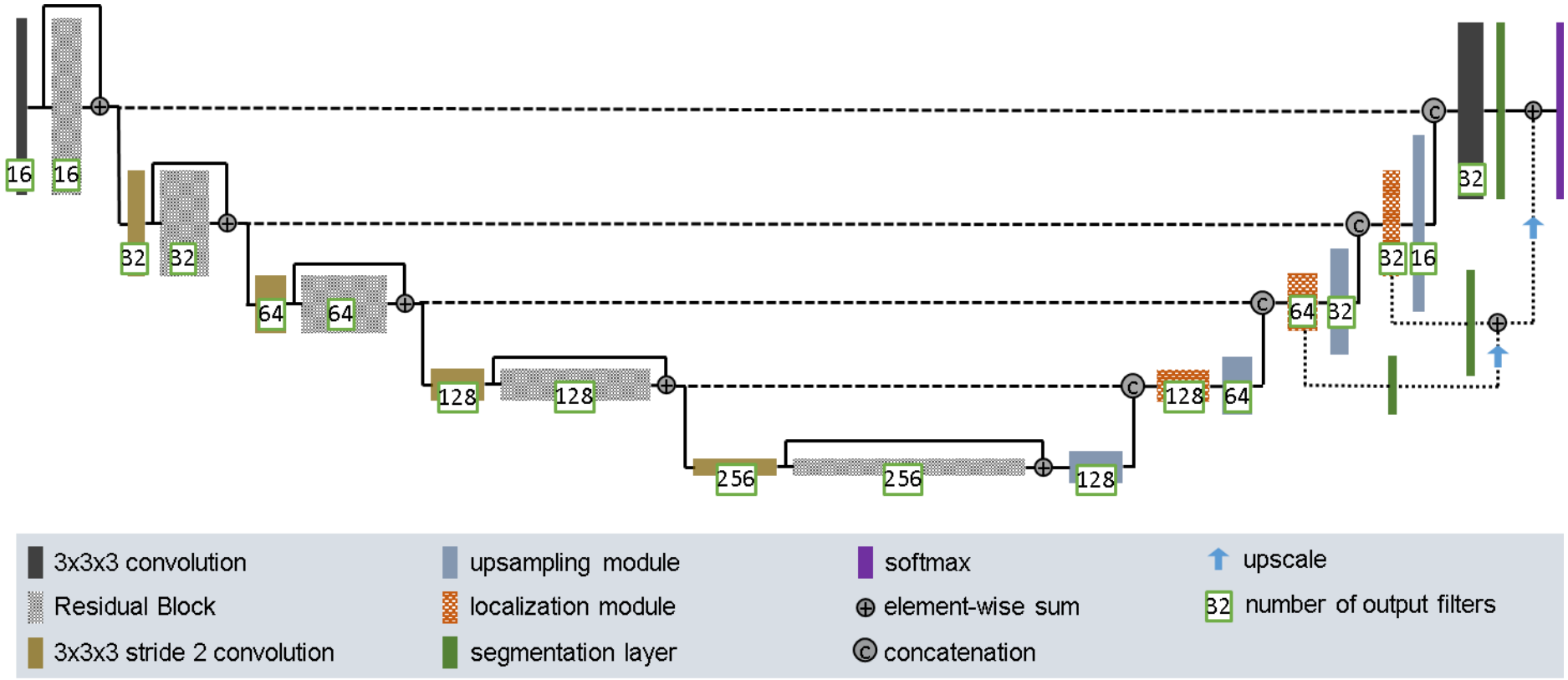
Milletari et al., 3DV, 2016
Sudre et al., DLMIA/ML-CDS (MICCAI), 2017
Drozdzal et al., DLMIA/LABELS (MICCAI), 2016

Medical Image Segmentation – Example: BraTS



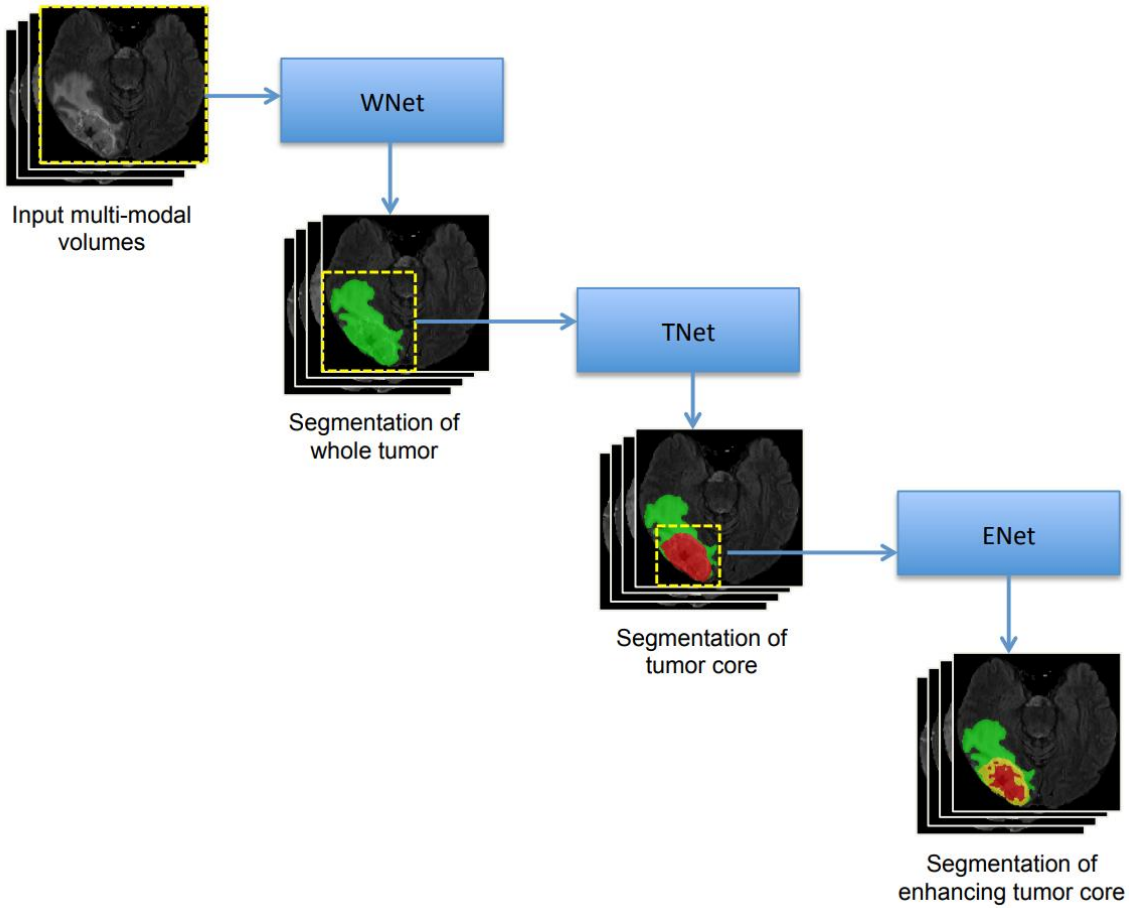
www.braintumorsegmentation.org

BraTS 2017 3rd Place (you can get a long way with a well trained UNet)



- Train on large patches (128x128x128)
- DICE loss
- A lot of data augmentation

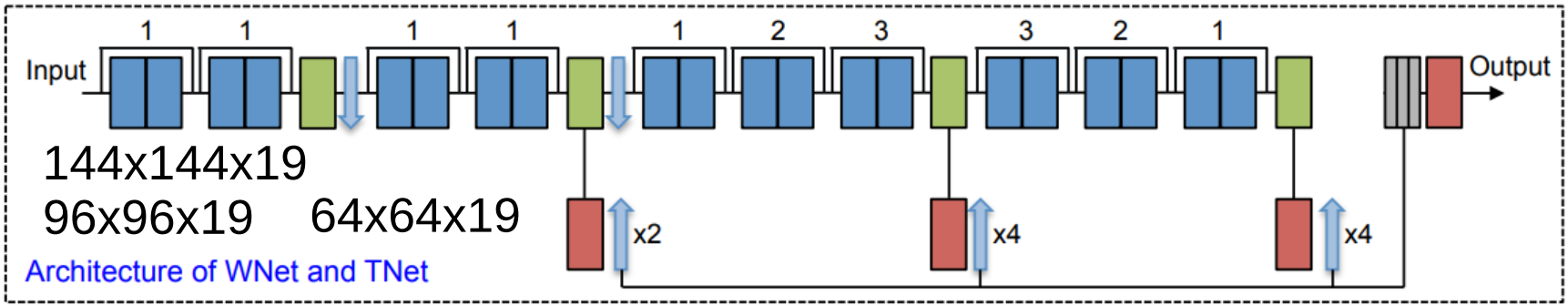
BraTS 2017 2nd Place

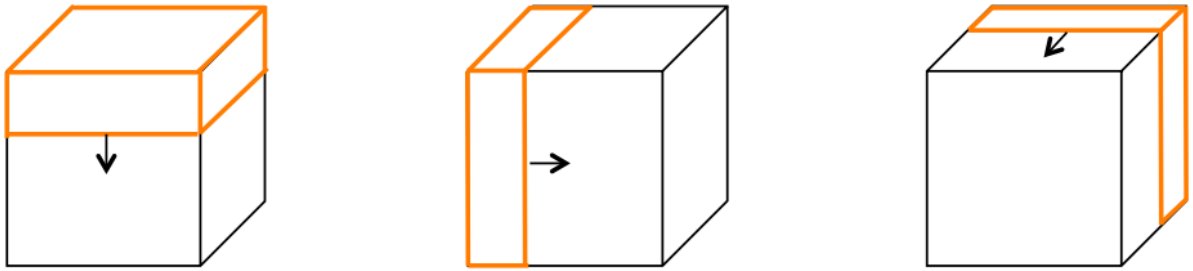


Cascade: simulate annotation procedure

Wang et al., MICCAI-BRATS, 2017

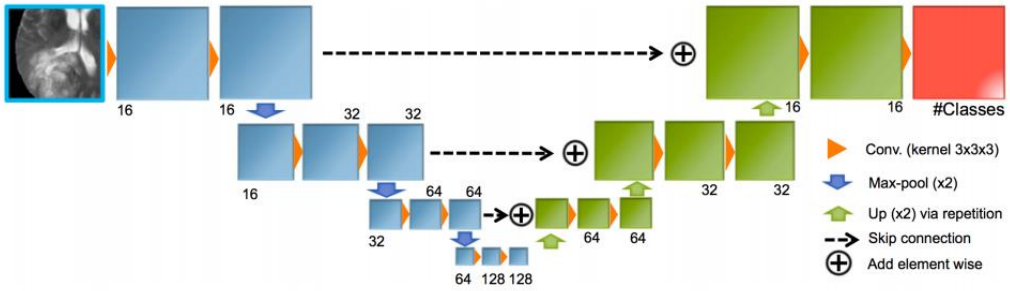
BraTS 2017 2nd Place



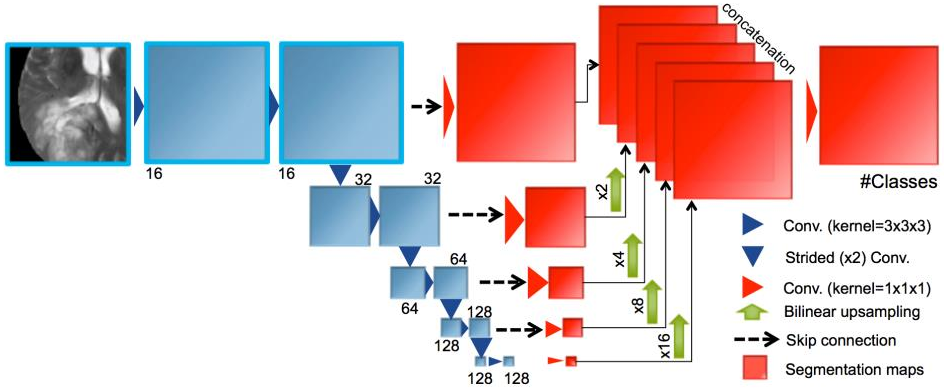


Wang et al., MICCAI-BRATS, 2017

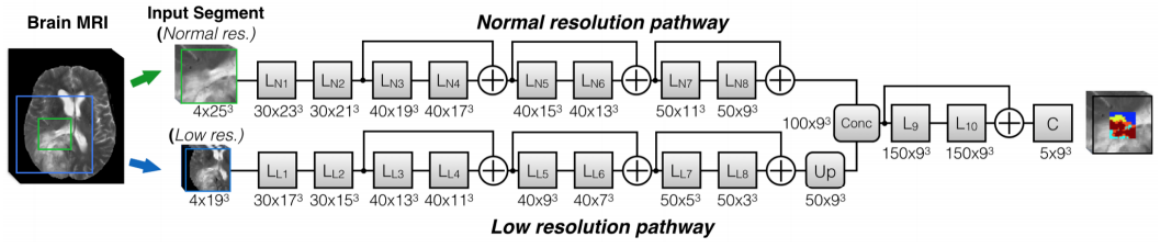
BraTS 2017 1st Place



UNet (3D)



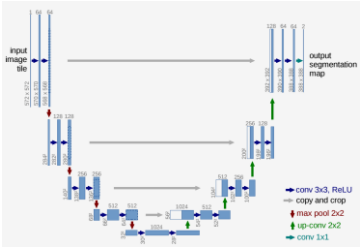
FCN (3D)



DeepMedic

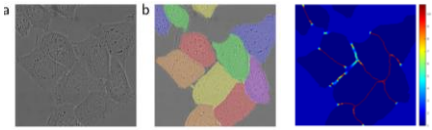
Kamnitsas et al., MICCAI-BRATS, 2017

Segmentation in Medical Image Computing: Short Summary

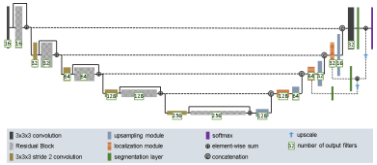


- Use Encoder-Decoder with OS1
- Think about your loss function

$$L_{DICE}(p,g) = -\frac{2}{|K|}\sum_{k\epsilon K}\frac{\sum_{i\epsilon N} p_{i,k}g_{i,k}}{\sum_{i\epsilon N} p_{i,k} + \sum_{i\epsilon N} g_{i,k}}$$



- Properly aggregate semantic information



- Data Augmentation

- Ensembling

dkfz.

Thank you!