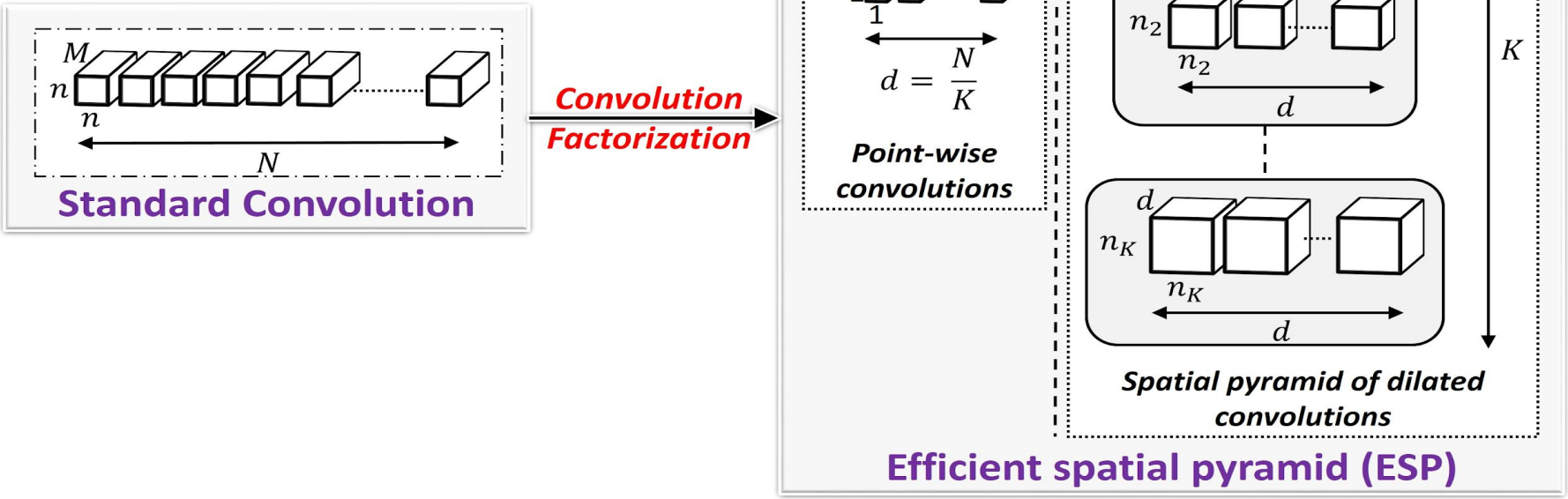
MRI Brain Tumor Diagnostics

with ESPNet & UNet Models

NMR Imaging

- Magnetic Resonance is an advanced technique used to produce images with magnetic force vectors and radio electrolysis at the lamar frequency of precession in water molecules.
- For this particular instance of image processing, MRI does a great job of describing tumors if for no other reason than tumors have a tendency to have higher volumes of water than the rest of the brain.
- The image files of MRI are quite varied and generally come in the form of mha or dicom files.


M
n
n
N
Standard Convolution
Convolution
Factorization
Step 1: Reduce
M
1
1
d = N/K
Point-wise convolutions
Step 2: Split and Transform
d
n1
n1
d
d
n2
n2
d
K
d
nK
nK
d
Spatial pyramid of dilated convolutions
Efficient spatial pyramid (ESP)

ESPNet Model

- This was a use case implementation of the author's ESPNet model with class source code.
- https://arxiv.org/pdf/1803.06815.pdf
- ESPNet is a semantic segmentation model that geometrically localizes, and classifies types of tumor, generating prediction masks based on a set of ground truth labels from which it learns.
- It is said to be an improvement of former CNN models and efficient in terms of power, computation, and memory.
- Few modifications were made to the source code but only as a means to update when errors were encountered.

ESPNet Architecture

- The model gains its momentum and shape from the factorization principle.
- The 3D convolutional layer is factorized into pointwise convolutions and then resampled at higher dimensions in steps.
- The resampling of convolutions into dilated convolutions gives rise to the pyramid shape.
- The architecture allows for a gradual dilation of convolutions and for a 1×1 convolution to project high-dimensional feature maps onto a low-dimensional space.

ESPNet Metrics/Results

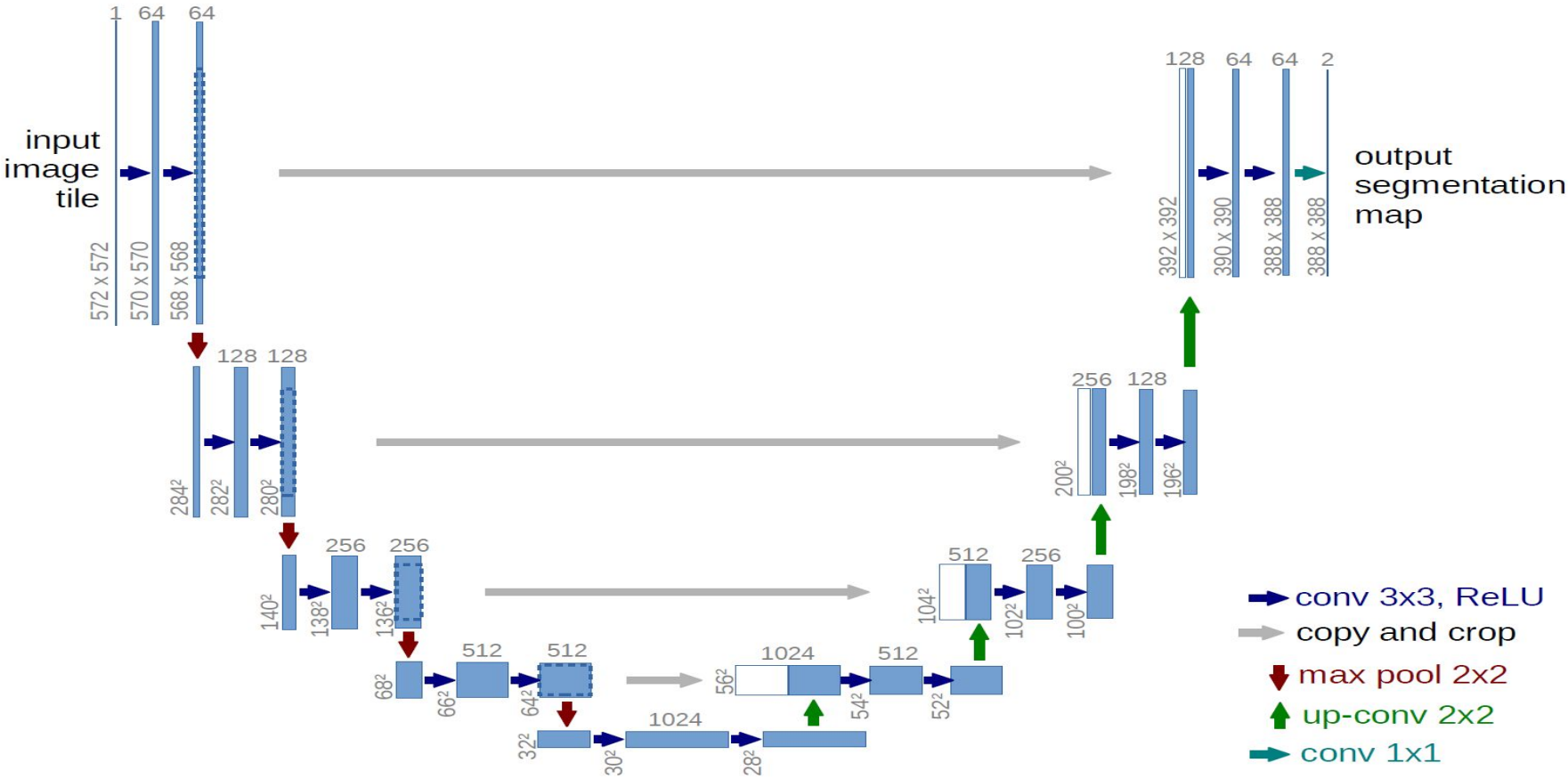
One class prediction:

- Epoch: 0
- Learning rate: 0.0005
- Train Loss = 0.9929
- Val Loss = 0.9285
- mIOU(tr) = 0.2489
- mIOU(val) = 0.2788

Summary: Prediction accuracy was very high for the class we intended to predict. IOU metric is commonly used in image analysis. The IOU score is low due to the nature of the formula measuring accuracy over all classes but high for the class alone.

UNet Model

- This is simplified implementation of the UNet drawing most of the strength from the fastai library.
- Preprocessing of the data prior to modeling requires not so much labor as extracting of file paths and recommended slice normalization and finally, conversion to numpy array data type.
- The UNet model is most notable as having been designed specifically for biomedical diagnostics by Olaf Ronneberger.
- https://arxiv.org/pdf/1505.04597.pdf
- https://lmb.informatik.uni-freiburg.de/people/ronneber/u-net/


input image tile
1
64
64
572 x 572
570 x 570
568 x 568
128
128
284²
282²
280²
256
256
140²
138²
136²
512
512
68²
66²
64²
1024
32²
30²
1024
28²
512
56²
54²
512
52²
512
256
104²
102²
100²
256
128
200²
198²
196²
128
64
64
2
392 x 392
390 x 390
388 x 388
388 x 388
output segmentation map
conv 3x3, ReLU
copy and crop
max pool 2x2
up-conv 2x2
conv 1x1

UNet Architecture

- The architecture is described as having a U-shape and has this shape because of downsampling in the convolutional process until the minimum threshold is reached at which point the model begins to upsample with concatenation of previously downsampled convolutional layers.
- The special treatment of data in this model happens to come from the retention of old information from the downsampled convolutions. So it is the concatenation, which is gives improvement results.

brats_fastAI_FINAL.ipynb

epoch	train_loss	valid_loss	acc_classwise	time
0	0.029111	0.024839	0.330450	1:23:32
1	0.022276	0.023739	0.323115	08:57
2	0.021362	0.018043	0.581657	08:49
3	0.020427	0.016716	0.625652	08:44
4	0.021608	0.017775	0.572800	08:39
5	0.350161	0.033714	0.159612	08:36
6	0.023126	0.021284	0.464602	08:32
7	0.020515	0.017754	0.611279	08:32
8	0.019133	0.017791	0.526095	08:32
9	0.014358	0.012924	0.691121	08:32

More on Metrics/Results

- This model also uses IOU as its metric and even though the BraTS 2015 data in this model differs from 2018, 2019 data used on the ESPNet, it retains the same schema with 5 classes of tumors, training data coupled with ground truth mask/labels.
- This model measures class-wise accuracy across all tumor types instead of one class alone.