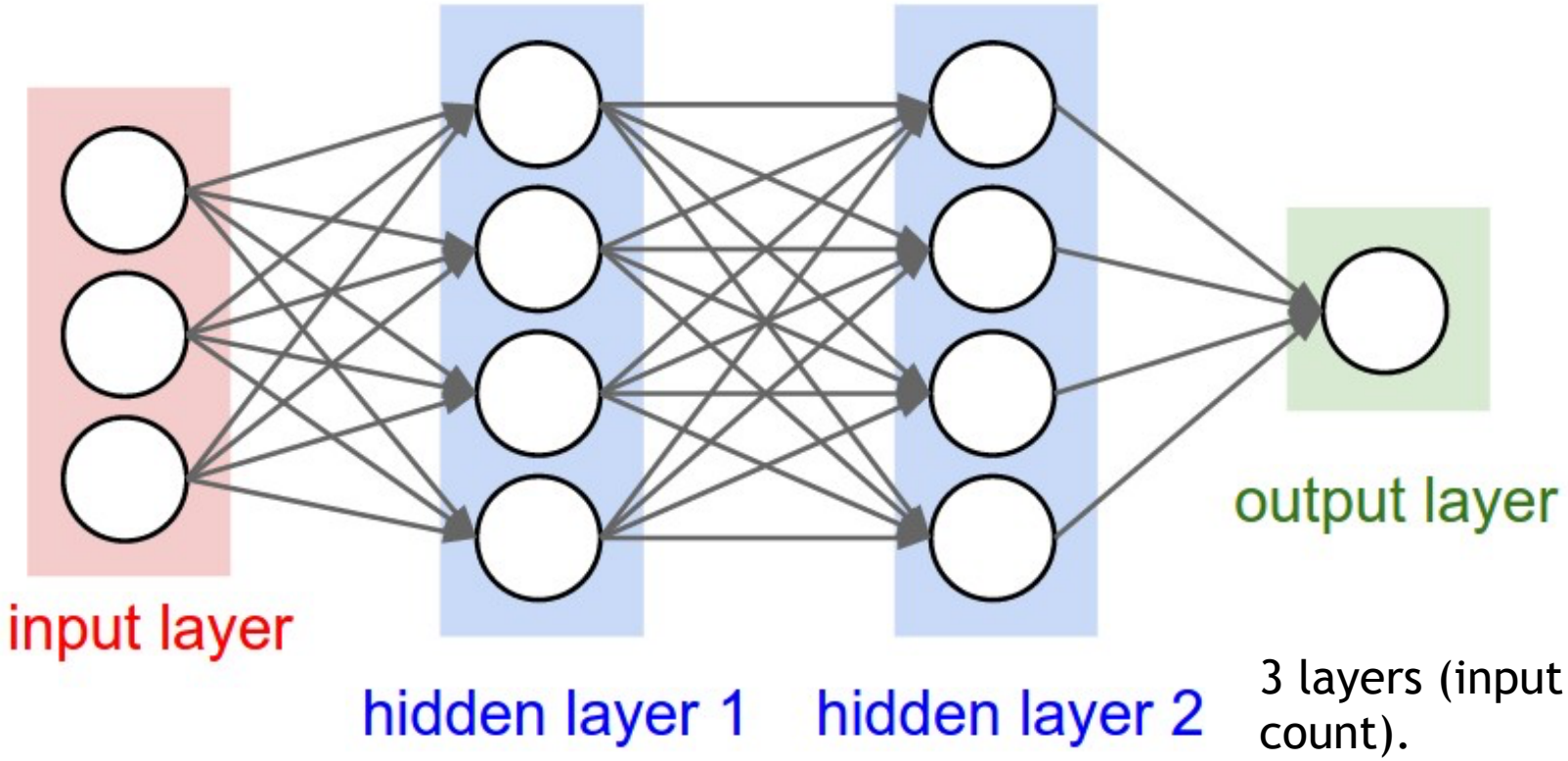
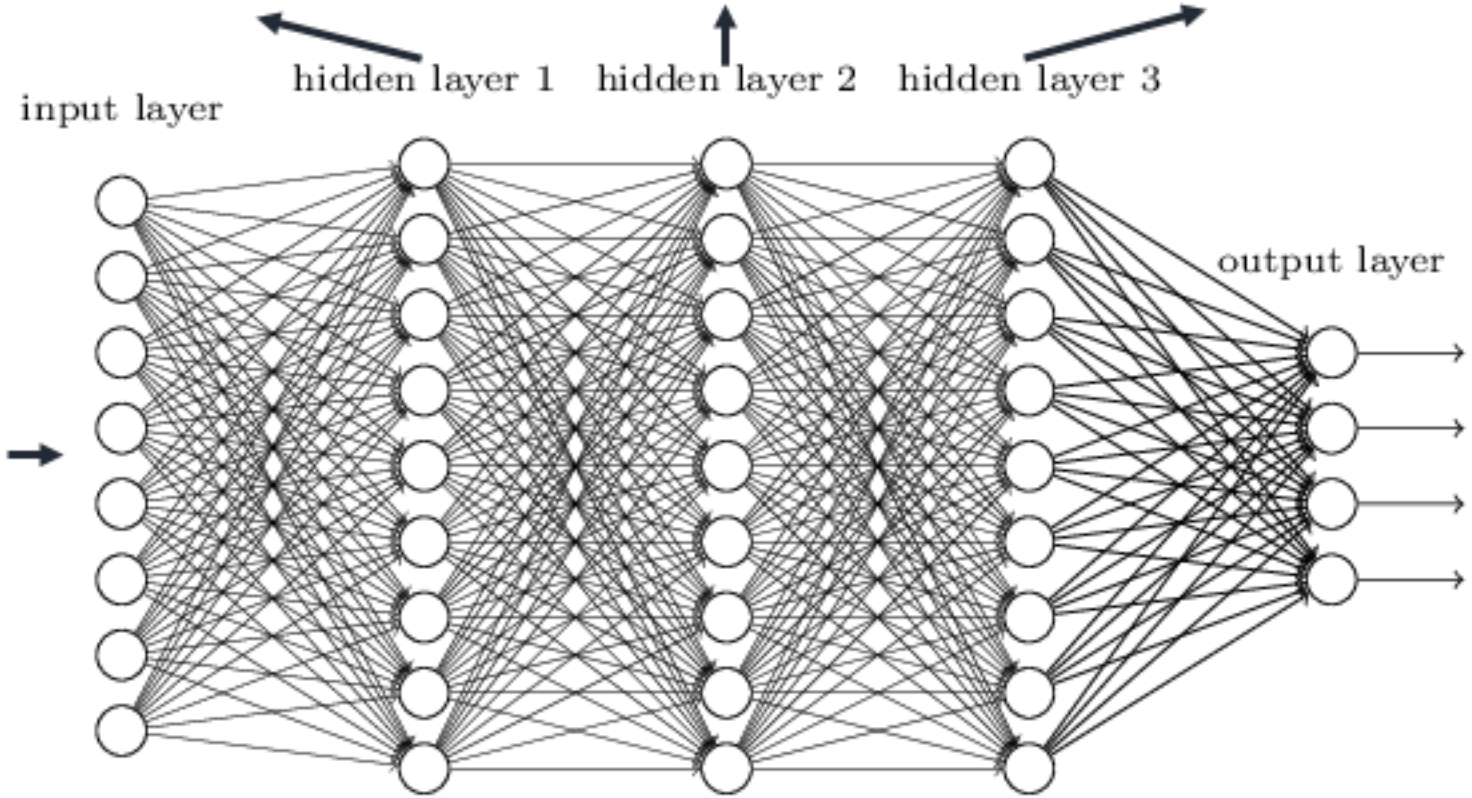
Deep Learning for Medical Imaging

(Fully Connected) Neural Networks

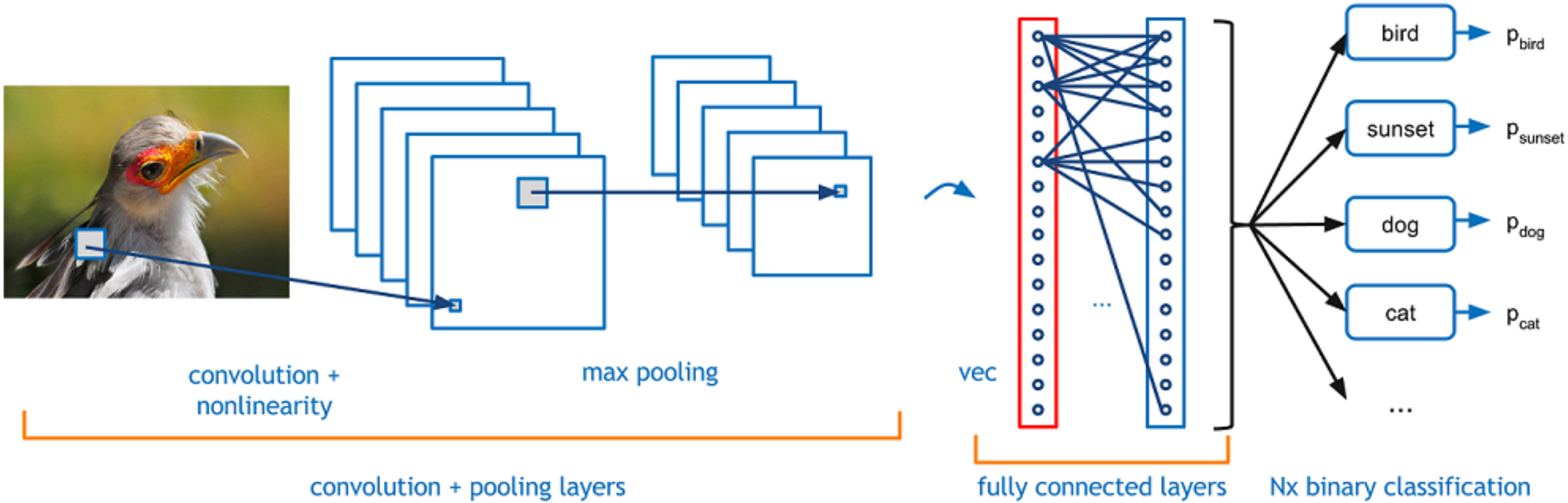


3 layers (input layer does not count).
The hidden layers have 4 hidden units each.

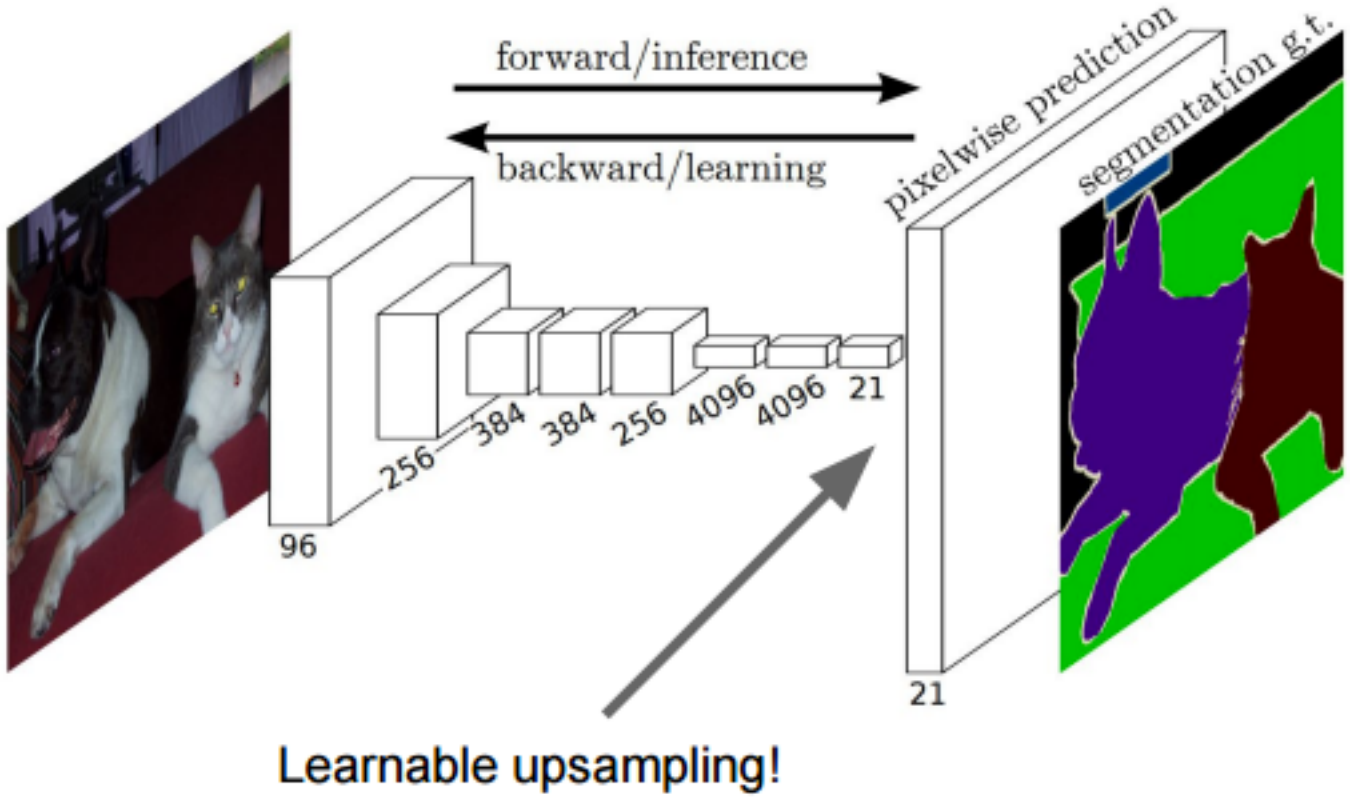
Deep neural networks learn hierarchical feature representations

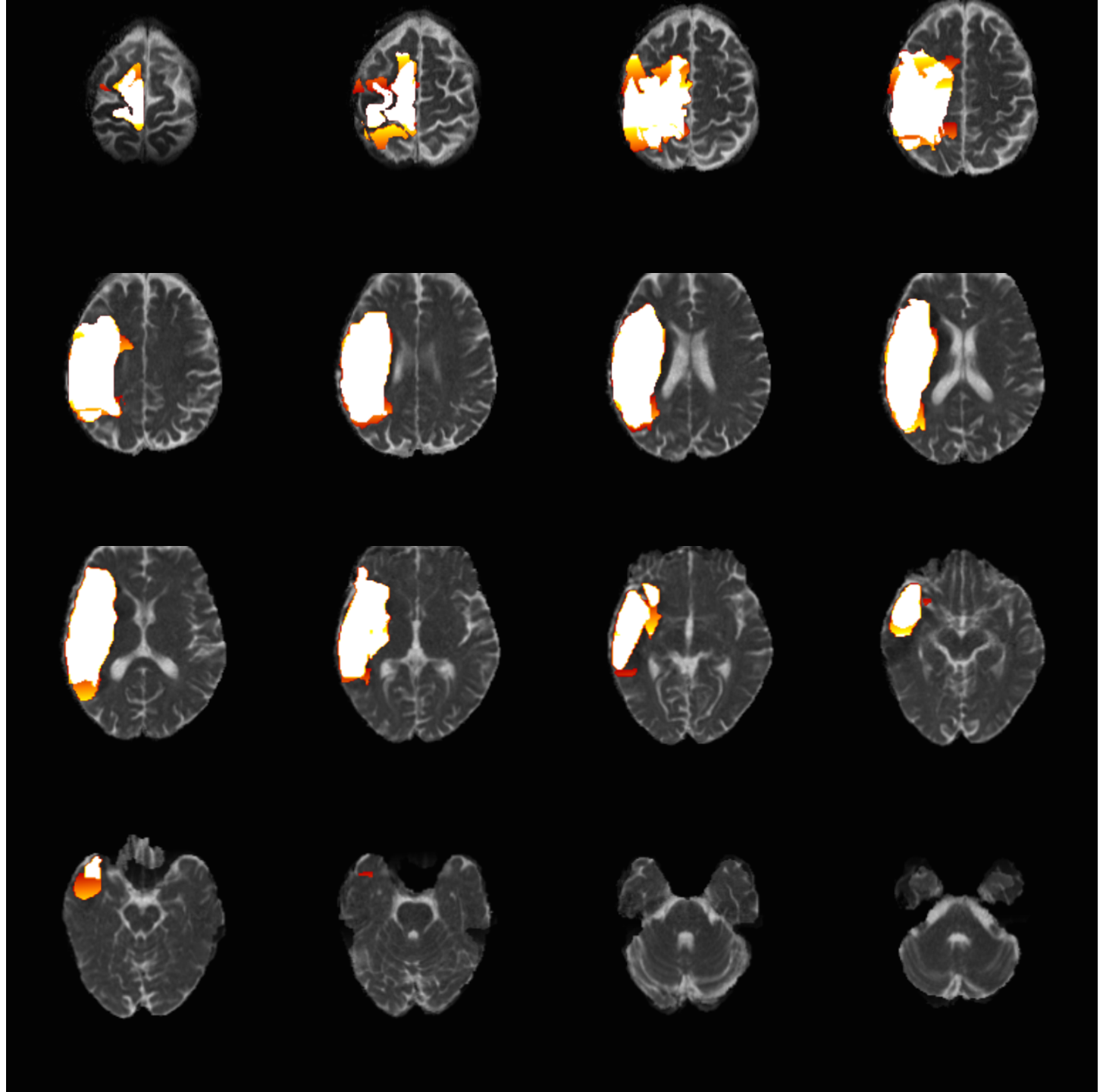


Convolution Neural Network (CNN)



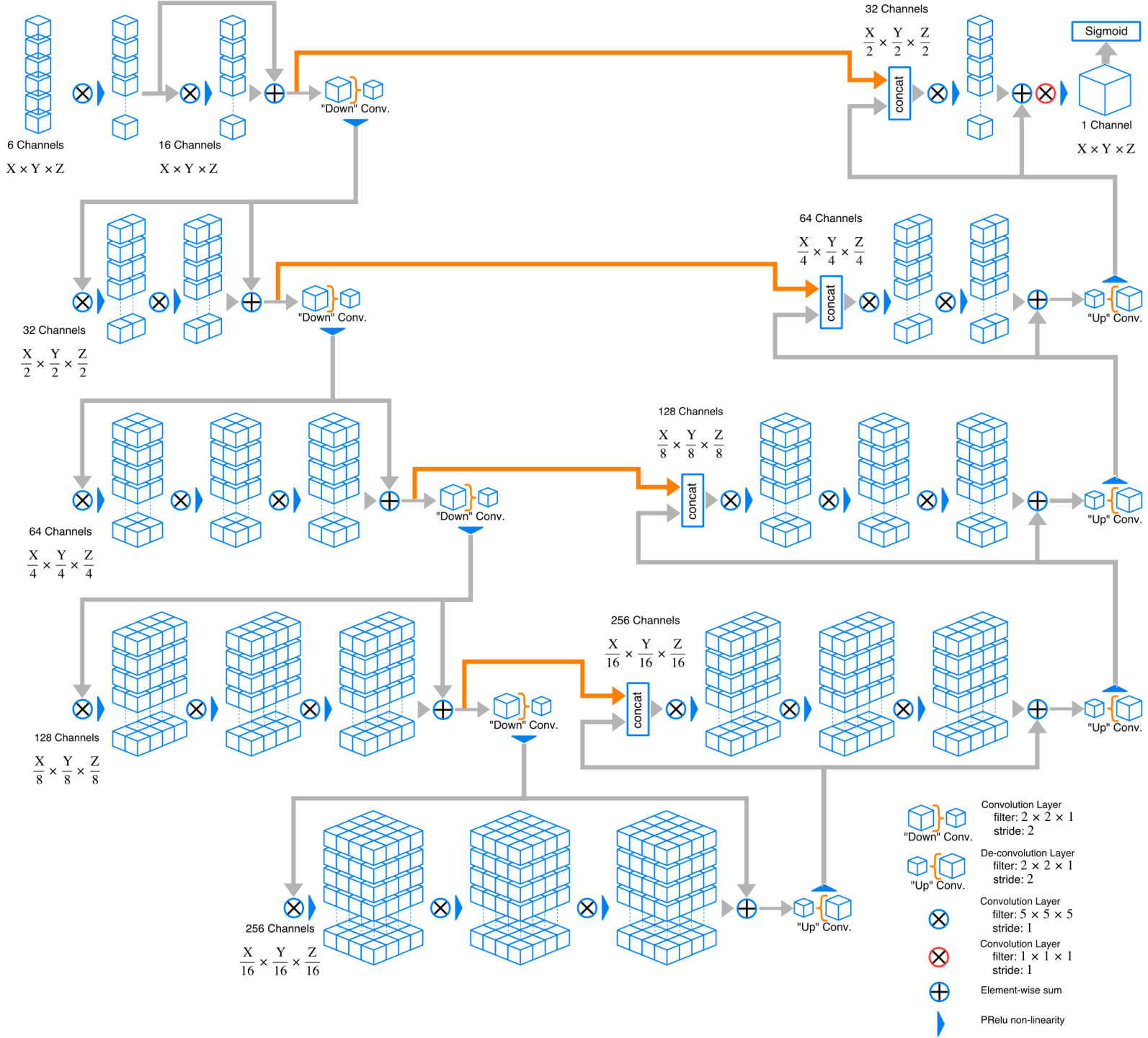
Fully Convolutional Neural Network (FCNN)





Setup

- Goal: To predict the outcome segmentation of a stroke lesion 90 days after the stroke had occurred using only MRI data collected the day of the stroke;
- Motivation: doctors can see the lesion just fine immediately after the stroke, what is harder is to know how the lesion will evolve over time;
- Data: 43 patients: 3D images with 6 channels each, but with varying spatial dimensions $(width \times height \times depth \times 6)$
- The ground-truth segmentation used for training was done by experts;
- Architecture: “V-Net” a FCNN used for 3D medical image.


6 Channels
X × Y × Z
16 Channels
X × Y × Z
"Down" Conv.
32 Channels
X/2 × Y/2 × Z/2
concat
Sigmoid
1 Channel
X × Y × Z
32 Channels
X/2 × Y/2 × Z/2
"Down" Conv.
64 Channels
X/4 × Y/4 × Z/4
concat
"Up" Conv.
64 Channels
X/4 × Y/4 × Z/4
"Down" Conv.
128 Channels
X/8 × Y/8 × Z/8
concat
"Up" Conv.
128 Channels
X/8 × Y/8 × Z/8
"Down" Conv.
256 Channels
X/16 × Y/16 × Z/16
concat
"Up" Conv.
256 Channels
X/16 × Y/16 × Z/16
"Up" Conv.
"Down" Conv.
Convolution Layer
filter: 2 × 2 × 1
stride: 2
"Up" Conv.
De-convolution Layer
filter: 2 × 2 × 1
stride: 2
Convolution Layer
filter: 5 × 5 × 5
stride: 1
Convolution Layer
filter: 1 × 1 × 1
stride: 1
Element-wise sum
PRelu non-linearity

Evaluation Metrics

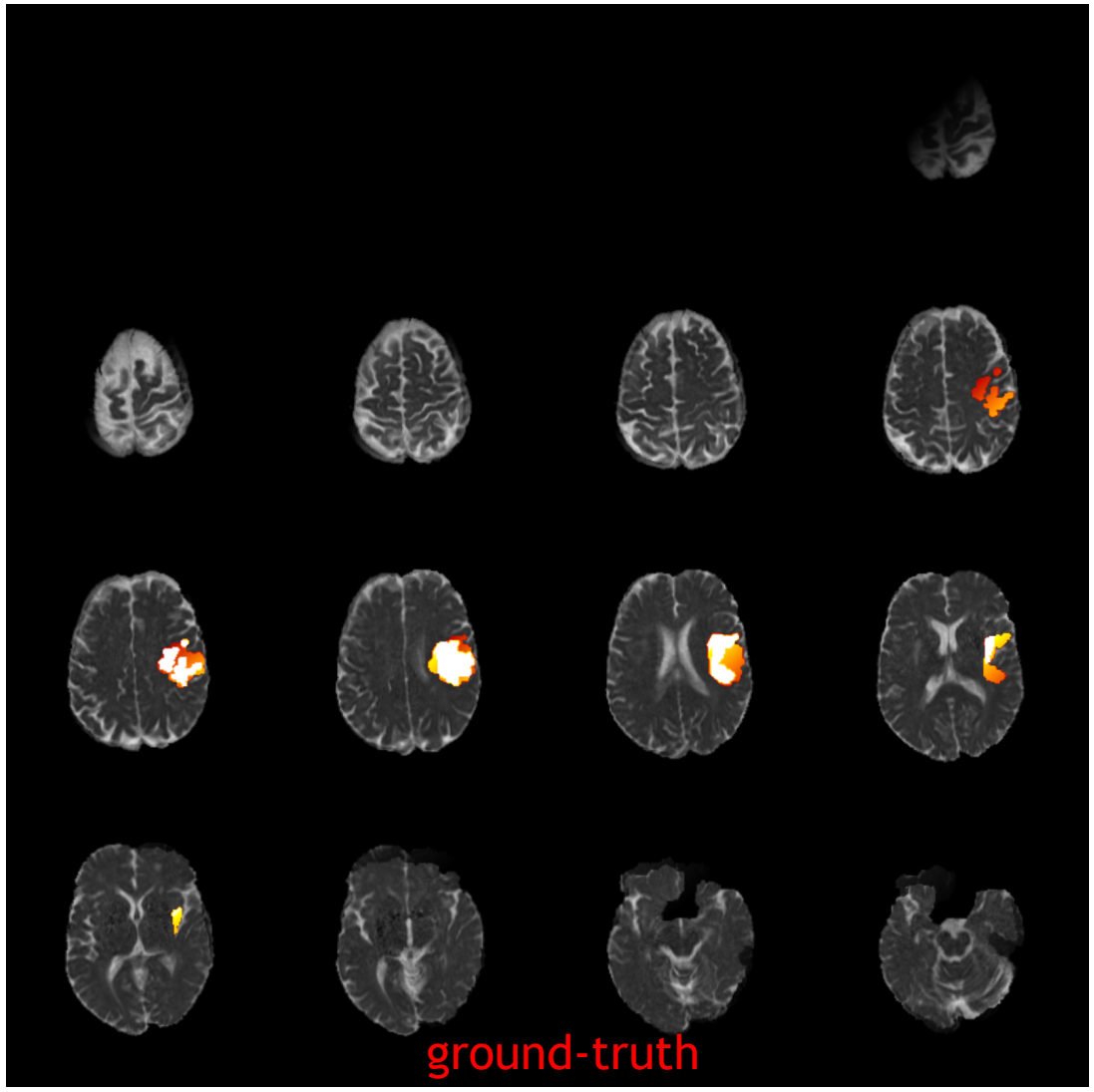
- Dice Coefficient (DC):
  - The fraction of overlap between the ground-truth segmentation and the prediction;
  - A number between 0 and 1, being that 1 corresponds to a perfect segmentation;
- Hausdorff Distance (HD):
  - Measures the presence of outliers in the segmentation;
- Average Symmetric Surface Distance (ASSD):
  - Measures the overall surface deformity between the ground-truth and prediction.

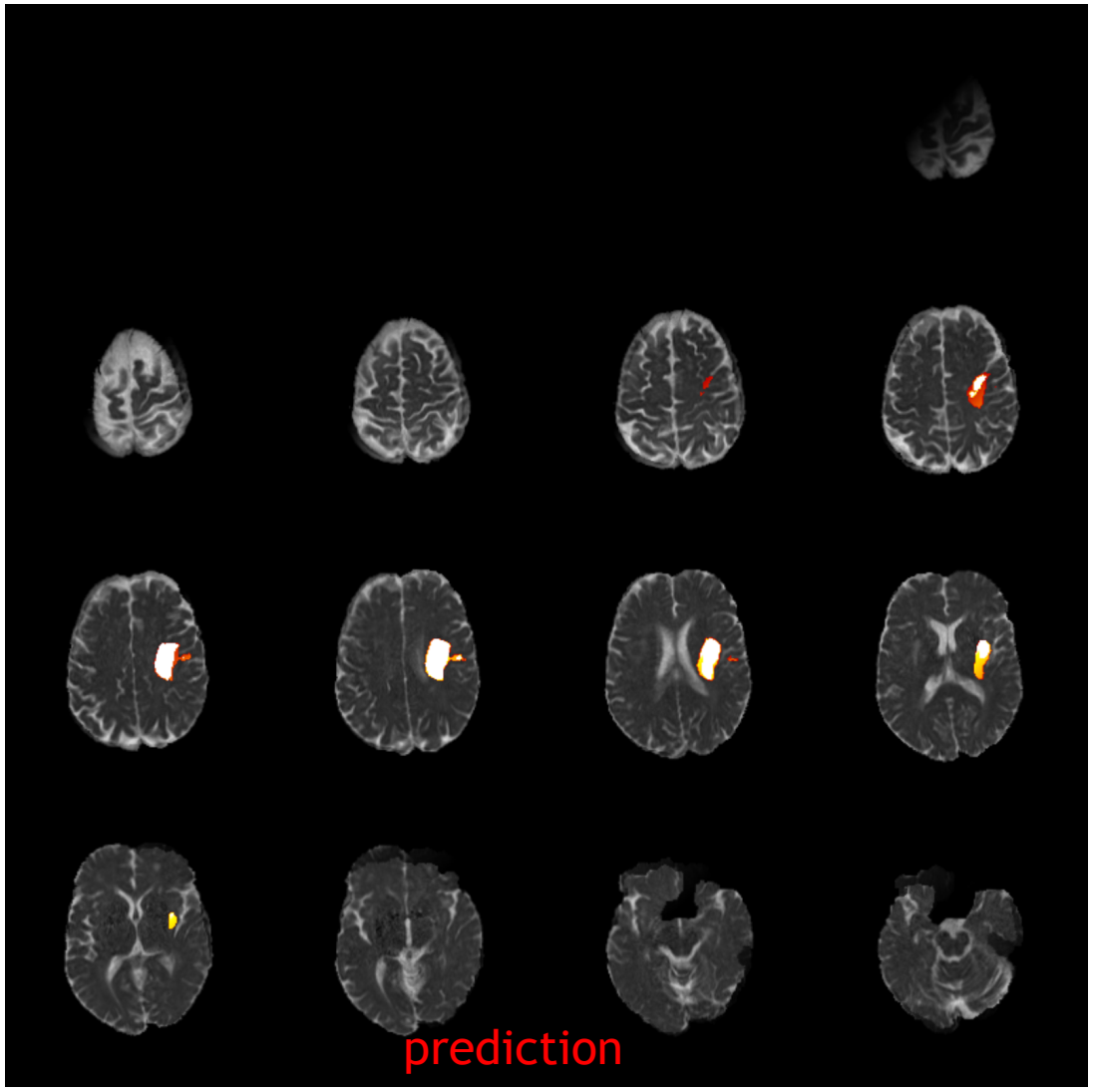
Results

	Raw Prediction	Post-Processed	Mean Gain
DC	0.357 ± 0.216	$\mathbf{0.370 \pm 0.215}$	3.662%
HD	30.823 ± 18.512	$\mathbf{23.398 \pm 18.753}$	24.091%
ASSD	4.426 ± 3.546	$\mathbf{3.722 \pm 3.389}$	15.895%

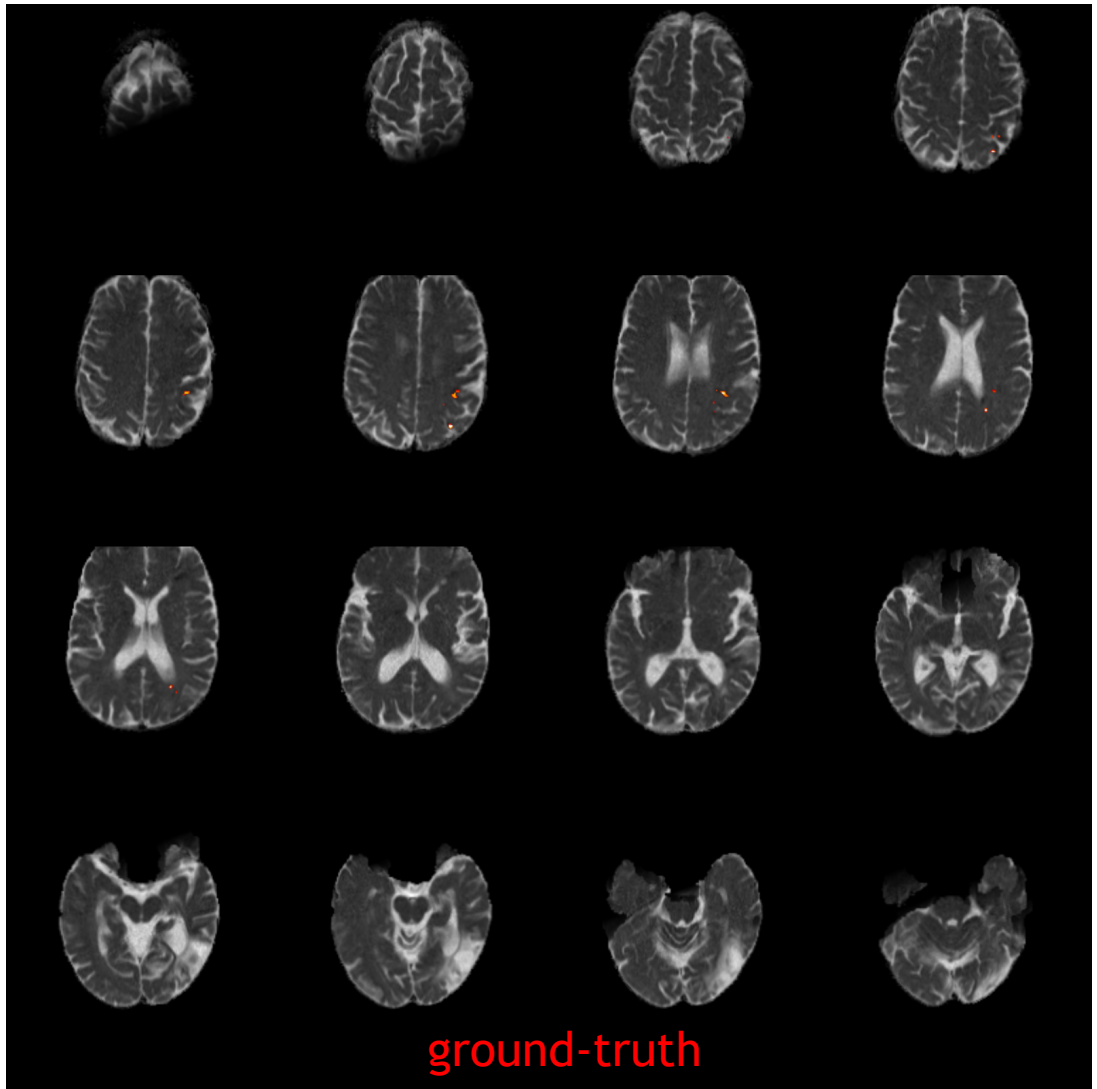
- Post Processing: remove any unconnected regions that had a volume smaller than 50% of the largest volume.
- This is because stroke lesions have one core and surrounding penumbra, usually there are not multiple unconnected affected regions;

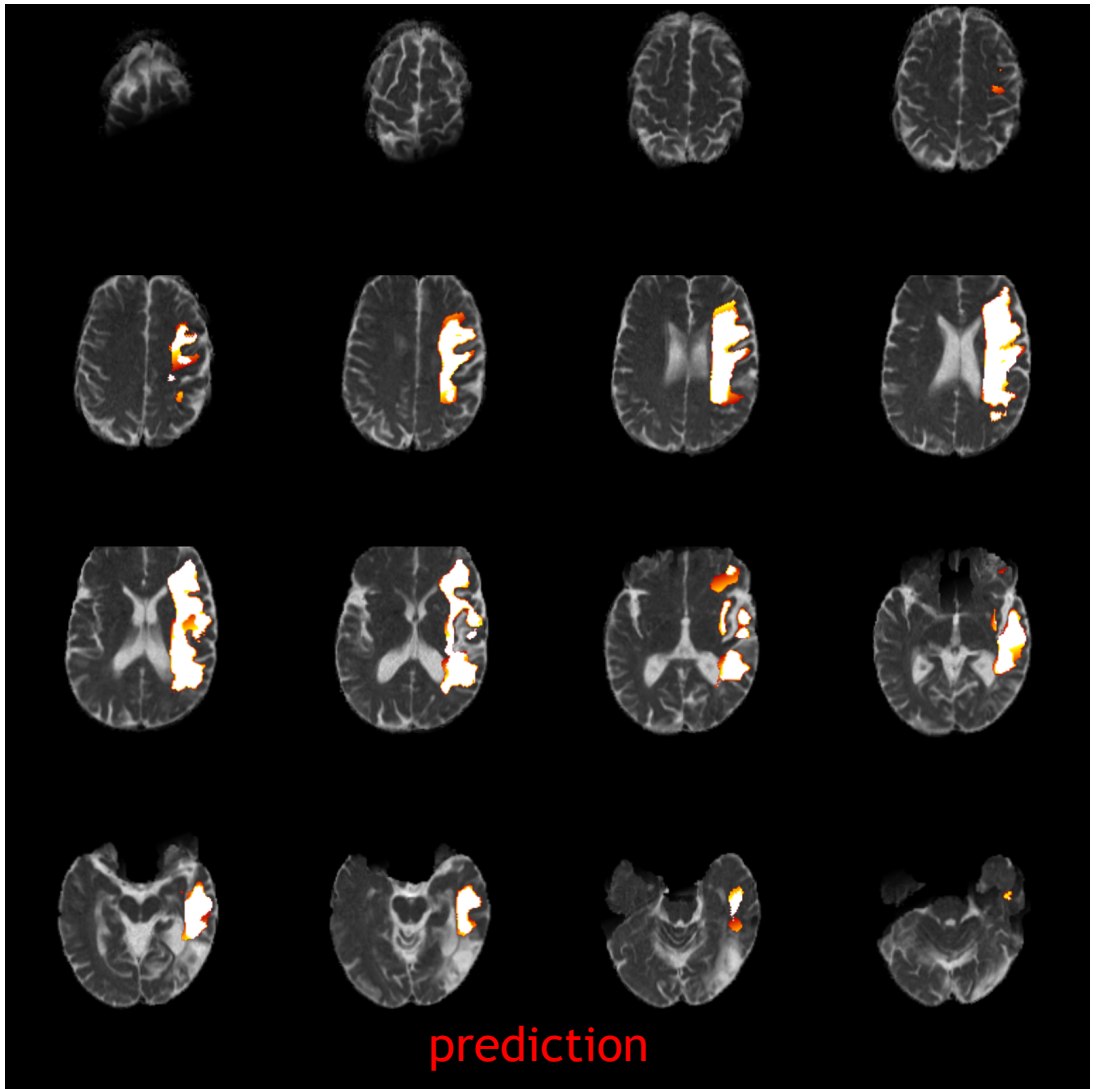
Median Case (DC = 43%)





Worst Case (DC = 0%)





Best Case (DC = 73%)