# Course: Image Segmentation with Python


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### Python Technology stack

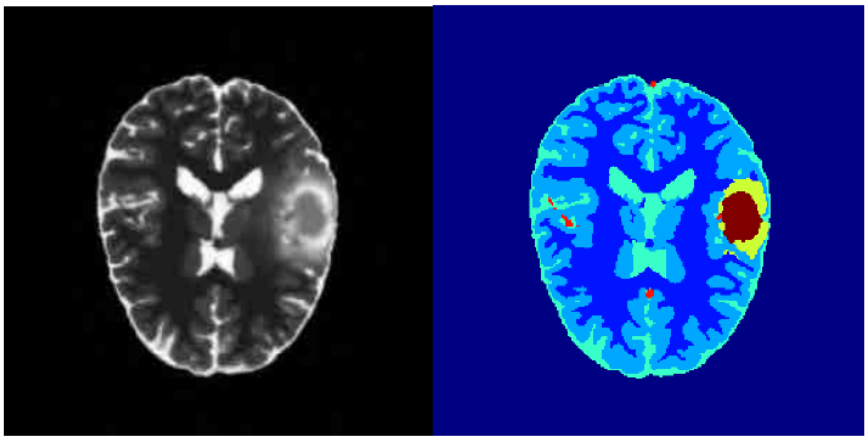
- NumPy
- TensorFlow and Keras
- Sckit-image
- OpenCV
- Google's Colaboratory

### Related courses

- Deep Learning in Python
- Convolutional Neural Networks for Image Processing

## Part 1: Image Segmentation Basics

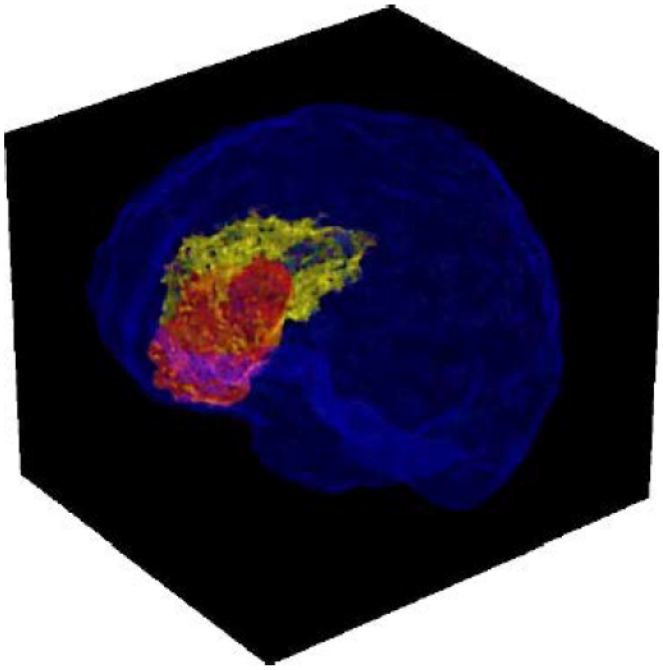
- Intro video explaining what image segmentation is (5-10 min)



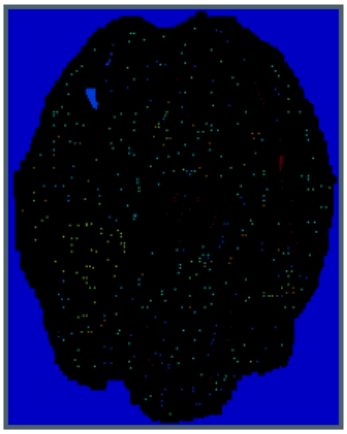
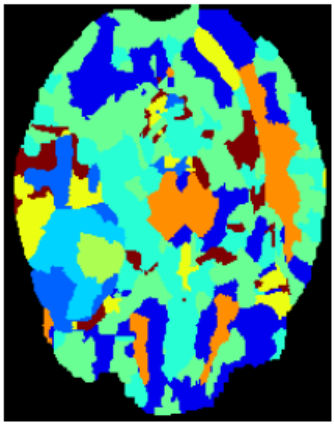
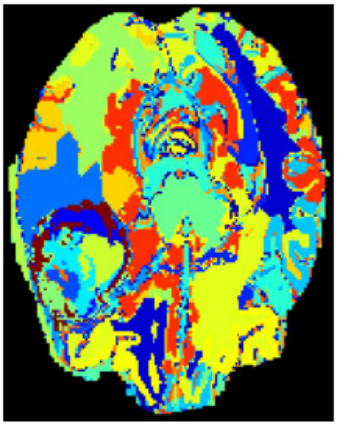
Synthetic MRI slice generated by TumorSim | Ground truth for 10 tissue classes, including tumor and edema

- Loading an image with OpenCV
    - Importing medical image data with PyDICOM
- Using a mask to select regions of an image

    - Select the tumor region in brain MRI



    - Visualizing the tumor region in 3D
- Quick multiple choice quiz about image segmentation (purpose of segmentation, use of masks)
- Intro video explaining segmentation with the GrowCut cellular automaton (5-10 min)
- Seeded segmentation with the GrowCut cellular automaton
    - Complete a Numpy implementation of the GrowCut cellular automaton
    - Using entropy minima as segmentation seeds
    - Labeling entropy minima with k-medoids
    - Defining minima area for segments to avoid oversegmentation

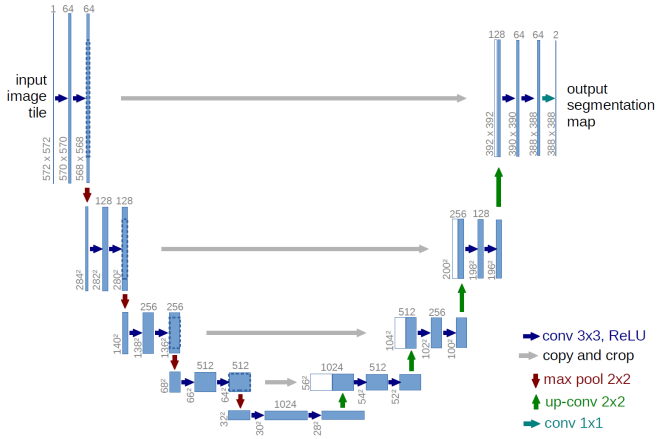




- Evaluating the quality of a segmentation
    - Counting true positives, true negatives, false positives, and false negatives
    - Computing precision
    - Computing recall
    - Computing the f1-measure
    - Computing Intersection over Union (IoU)
    - Computing the warping error
    - Computing the Rand error

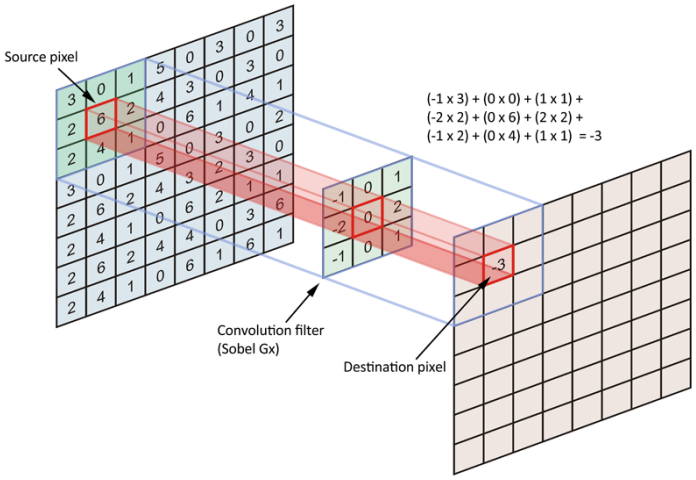
# Part 2: Understanding U-net part 1

### Segmenting biomedical images

- Intro video explaining what U-net is and how does deep learning enables automatic image segmentation (5-10 min)
    - *The intro video mentions the encoder-decoder architecture of U-net and how part 2 focuses on the encoder, part 3 on the decoder, and part 4 on the final layers of U-net and its optimization*

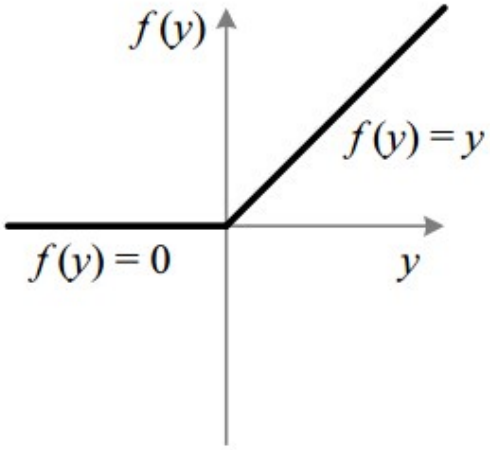


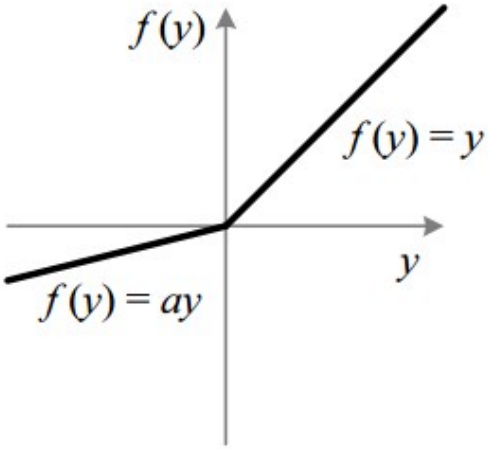

- U-net architecture
    - Quick multiple choice quiz about U-net's architecture (purpose of U-net, contents of layers, what convolution is, what upsampling is)




- Understanding image convolutions
    - Applying a convolution filter
    - Changing the weights of a convolution filter
- Video explaining the need of image cropping and data augmentation in U-net (5 min)
- Doing image cropping
- Doing data augmentation
    - Mirroring
    - Rotation
    - Vertical/horizontal flips
    - Deformations

- Video explaining the use of pooling (3 min)
- Understanding pooling
    - Implement max pooling
- Video explaining activation functions in U-net (3 min)



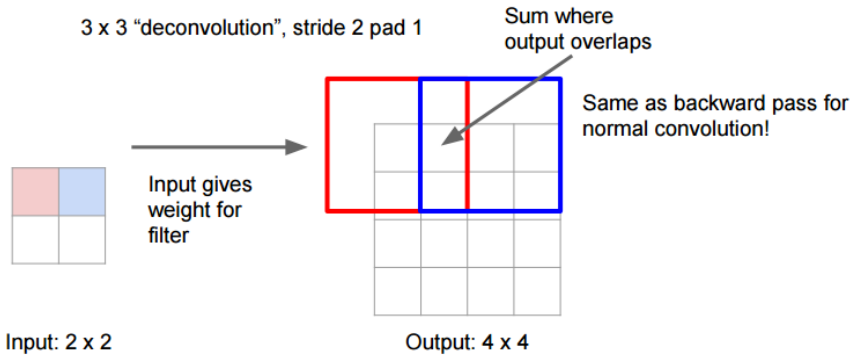




- Understanding ReLU
    - Implement Regular ReLU
    - Implement Leaky ReLU

## Part 3: Understanding U-net part 2

**Segmenting road images**

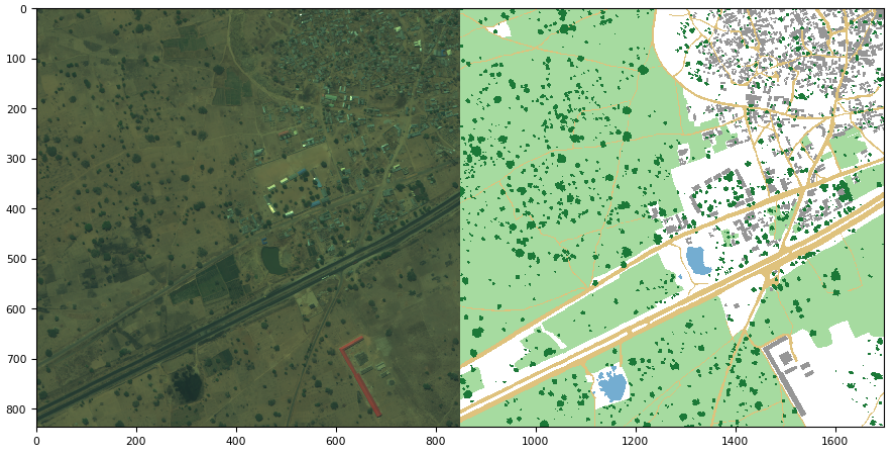
- Video explaining the decoder part of the U-net learning architecture, explains upsampling, mentions what unpooling and transposed convolutions are and their purpose (5-10 min)
- Understanding unpooling
  - Replacing each entry with an $n \times n$ matrix filled with the original entry (NumPy drill).
  - Replacing each entry with an $n \times n$ matrix with the original entry in the upper left and the other squares set to 0. [1506.02753] (NumPy drill)




- Computing a transposed convolution with tf.nn.conv2d_transpose

# Part 4: Understanding U-net part 3

**Segmenting multispectral satellite images**




Understanding the final layers and the loss function

- Video explaining loss functions (5 min)
- Quiz on loss functions
- Understanding loss functions:
    - Computing Cross entropy
    - Computing Mean squared error
    - Computing Mean absolute error
    - Using the Dice similarity coefficient as an error metric
- Video explaining optimizers (5 min)
- Choosing an optimizer:
    - Training a net with Stochastic Gradient Descent (tf.train.GradientDescentOptimizer)
    - Traning a net with ADAM (tf.train.AdamOptimizer)
- Video introduction to regularization and dropout (2-3 min)
- Regularization with Dropout
    - Regularization with tf.nn.dropout
- Video introduction to mathematical morphology operations (2-3 min)
- Mathematical morphology to define borders of the final segmentation mask
    - Eroding an image
    - Dilation an image
    - Finding borders on image by the composition of dilation and erosion
- Putting it all together
    - Comparing the performance of networks with different hyperparameters