Lab 5 - Medical image segmentation with U-net

1. Build a semantic segmentation model based on the U-net architecture. You can use an already implemented such model. You have examples in the following links:

   https://pyimagesearch.com/2022/02/21/u-net-image-segmentation-in-keras/
   https://becominghuman.ai/u-net-architecture-explained-and-implementation-470a5095ad57
   https://www.tensorflow.org/tutorials/images/segmentation
   https://asperbrothers.com/blog/image-segmentation/

2. Download the Brain Tumor dataset from:
   https://drive.google.com/file/d/1RyOkJ7yb45P0NCvVqrE3mtmtVgVqwRji/view?usp=sharing

3. Split the dataset in 70% train images (and masks) and 30% test images. Use as many images as your computer allows you.

4. Train de U-net model using the training set (if necessary, use augmentation) and then segment the images in the test set. Evaluate the efficacy of the segmentation task by computing the mean pixel accuracy, mean Jaccard's index (intersection over union) and mean Dice coefficient[1].

$$Pixel\ Accuracy = \frac{True\ Positive + True\ Negative}{True\ Positive + False\ Negative + False\ Positive + True\ Negative}$$

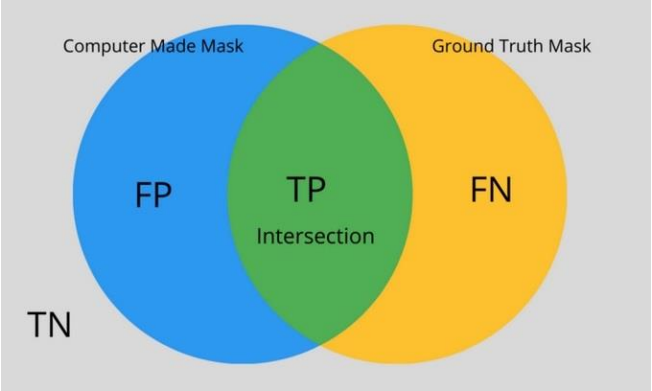
$$Jaccard's\ index = IoU(Intersection\ over\ Union) = \frac{TP}{TP + FN + FP}$$

$$Dice\ coefficient = \frac{2 * TP}{2 * TP + FN + FP} = \frac{2 * Intersection}{Union + Intersection}$$

5. Modify the U-net architecture, hoping to obtain better results. U-net variants

6. Test U-Net on the dataset from Homwork 3 (Pratheepan dataset)

[1] https://towardsdatascience.com/how-accurate-is-image-segmentation-dd448f896388



U-net

U-Net is a semantic segmentation convolutional neural network that was developed for biomedical image segmentation[2]. This model was developed to work with fewer training images (data augmentation with elastic deformations reduces the number of annotated images required for training) and yield more precise segmentation. Its key features are that U-Net learns segmentation in an end-to-end setting (one inputs an image and gets a segmentation map as the output). U-Net performs classification on every pixel so that the input and output share the same size.

U-net is a special type of encoder-decoder network (see Figure 1):

- encoder (left part of a "U") – encodes image into an abstract representation of image features by applying a sequence of convolutional blocks that gradually decrease representation's height and width but an increasing number of channels that correspond to image features.
- decoder (right part of a "U") – decodes image representation into a binary mask by applying a sequence of up-convolutions (NOT the same as deconvolution) that gradually increase representation's height and width to the size of the original image and decreases the number of channels to the number of classes that we are segmenting
- additionally, U-Net implements skip connections that connect corresponding levels of encoder and decoder. They allow the model not to "lose" features extracted by earlier blocks of an encoder, which increases segmentation performance.

[2] O. Ronneberger, P. Fischer, T. Brox, U-net: Convolutional networks for biomedical image segmentation, International Conference on Medical Image Computing and Computer-Assisted Intervention (2015) 234–241.

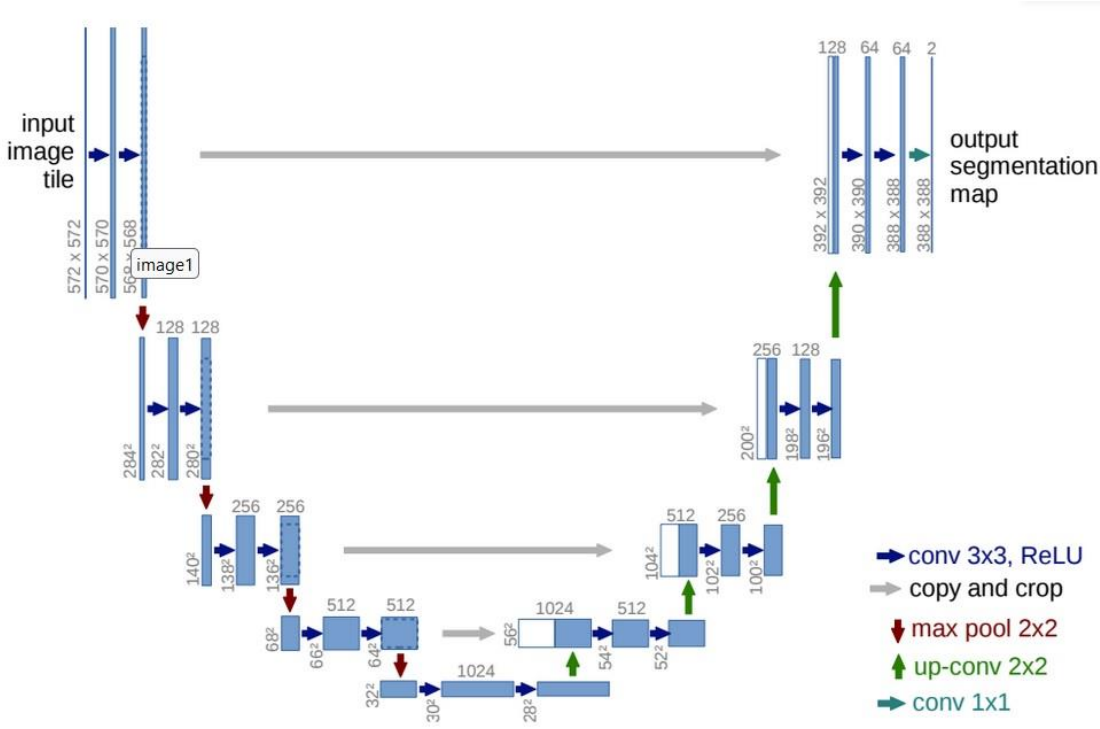


Figure 1 – U-net architecture