Team Shirin NF Hackathon 202...

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Using Deep Learning for NF tumor segmentation on MRI image stacks

Isaac Dimitrovsky[1] and Lars Warren Ericson[2]

1 WRQ Research. ikedim@gmail.com (mailto:ikedim@gmail.com), www.ikedim.com

2 Catskills Research Company, lars.ericson@catskillsresearch.com (mailto:lars.ericson@catskillsresearch.com)

Background/Intro

This describes our MRI segmentation entry to the CTF Hack for NF 2020. We investigated a Deep Learning approach, based on mentor feedback that this would be of interest.

- **Dataset**: 50 segmented MRI stacks (20 STIR images/stack).
- **Challenges**: small dataset; whole-body MRI with many different tumor sites, sizes, shapes; unbalanced (<1% pixels positive).

- **Techniques used**: Image processing; Transfer learning with pretrained dynamic UNet, 3 slice stack, 3D data augmentation, Focal-Tversky loss function.
- **Results:** seemed like a decent start (pixelwise F1 score >0.6 on validation set).
- **Future:** Try inpainting, better metrics.

Methods

Image preprocessing

Used method in (1).

Alternative to windowing - rescales DICOM data directly to floating point, using a histogram-based method to redistribute values evenly. Takes advantage of DL models ability to directly input floating point.

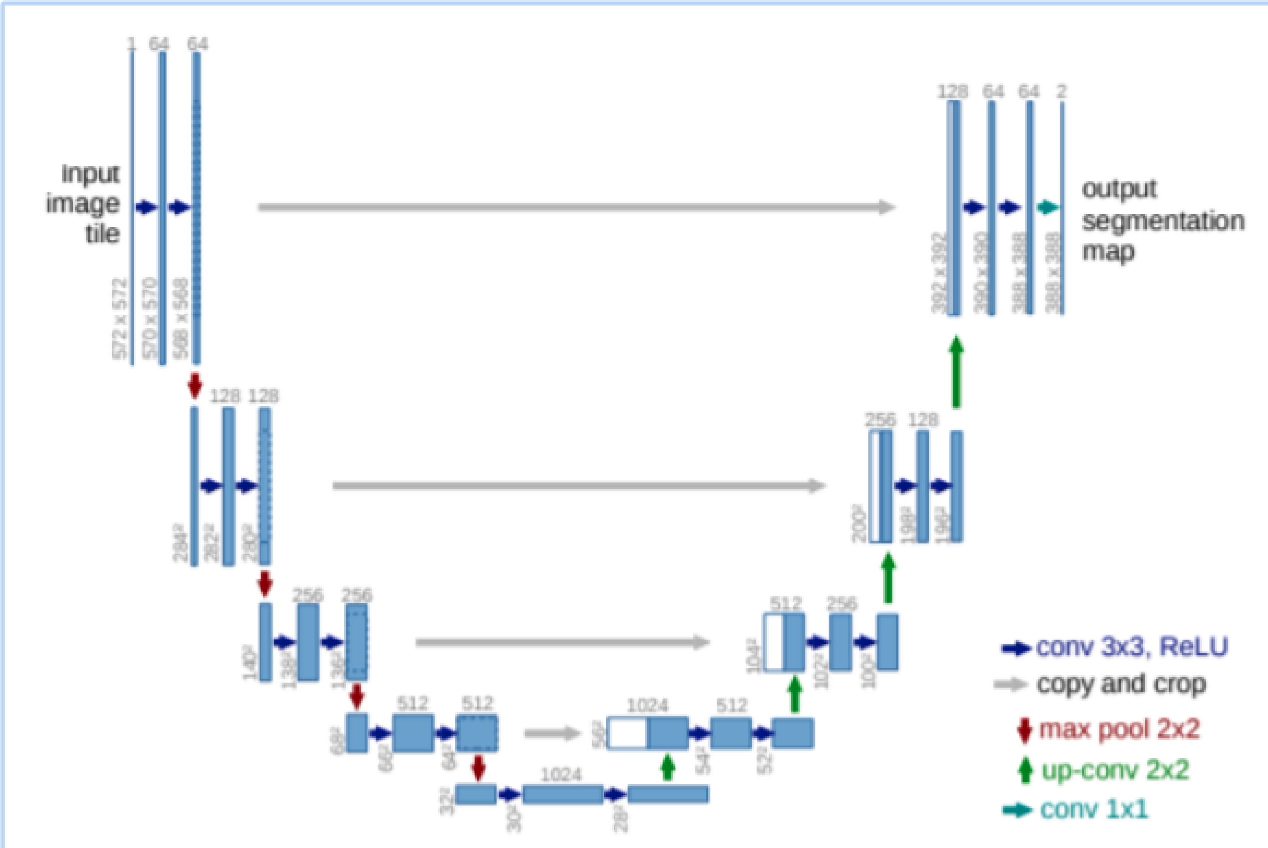
Rescaled high end of range to enhance contrast for tumor tissue.

```
[0.0 .. 0.75]  ->  [0.0 .. 0.25]          [0.75 .. 1.0]  ->  [0.25 .. 1.0]
```

U-Net

U-Net (see Figure 1) is a go-to architecture for medical image segmentation. (2)

Figure 1: U-Net



Transfer learning

Used U-Net with pretrained base to reduce training data required.

Fastai - Dynamic U-Net (3) - generates a U-Net for any image size, using a specified pretrained classifier as base.

Used full images (320x1100), no tiles.

Used 3 sliced U-Net with pretrained base to reduce training data required.

Fastai - Dynamic U-Net - generates a U-Net for any image size, using a specified pretrained classifier as base.

Used full images (320x1100), no tiles.

Used 3 slices of input stack as 3 channel input to 2D U-Net; this enabled using pretrained Resnet34 (4) as base architecture.

3D rotation for data augmentation

In addition to usual 2D data augmentation transforms, added rotates of the MRI image stack around the remaining 2 axes. (See Figure 2.)

Figure 2:

Loading...

Focal-Tversky loss function

We used the Focal-Tversky loss function.(6)

Results

Selected 5 stacks as validation set (patients 36,65,102,109,120); mix of low and heavy tumor burden.

Trained dynamic U-Net with pretrained Resnet34 base (10 epochs).

Achieved pixelwise F1 score >0.6 on validation set.

Discussion

Hypothesis

This problem may be difficult to train because of the low number of example tumor pixels, and the diverse background they can appear against.

Idea

Train a U-Net model to inpaint (5) MRI images, i.e. to fill in randomly inserted holes. This should enable the model to learn what “normal” pixels are in a context-dependent way, and we can use all the images for training (similar to training a language model in NLP). Then, base tumor prediction on the difference between actual values and those predicted by inpainting.

References

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Authors Statement

Isaac Dimitrovsky and Lars Ericson contributed equally to this work.

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