

HipMRI U-Net

2D U-Net for the HipMRI prostate cancer data

About

This is an implementation of a 2D U-Net based on [1] that tries to produce segmentations of the HipMRI data set.

Architecture and Implementation

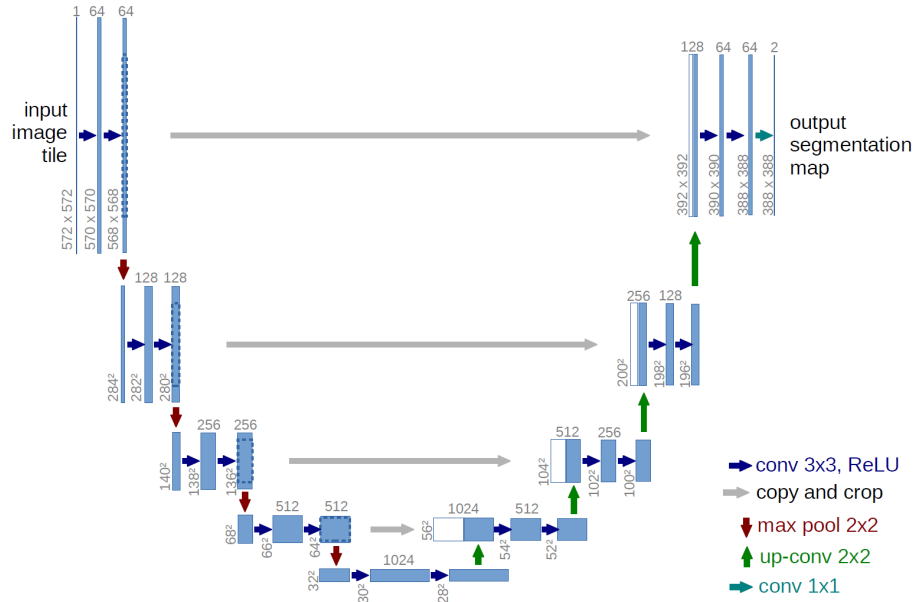


Figure 1: U-Net. Source: [1]

In essence I use almost the exact architecture as the original U-Net outlined in [1], but with one of the ‘U’ layers removed so that there are three encoder and decoder steps instead of four. This was due to the fact that the sizes of the images used in this problem are too small for the original architecture; it encoded to a tiny latent space of 8x8 pixels.

Another difference between my final model and the original U-Net [1] is that while the original had different input and output sizes (572x572 vs 388x388) my model has a consistent input and output size (an input of 256x256 pixel images, and an output of 256x256 pixel segment maps). This is mainly due to the fact that the original used unpadded convolutions [1] whereas I use a padding size of one. This is more consistent with examples seen in [2], [3], [4].

This was not the only U-Net architecture considered. An alternative from [2]

was also looked at:

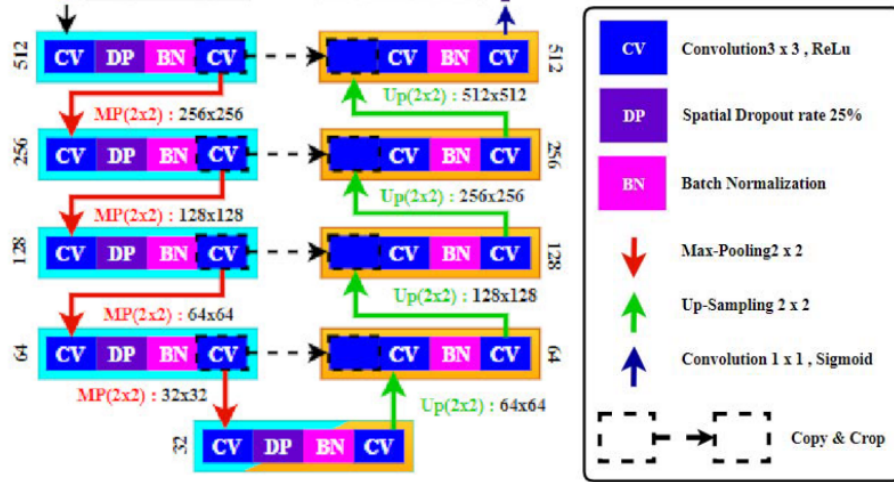


Figure 2: Alternative U-Net, Source: [2]

The only real difference between this and [1] is that this has 25% spatial dropout layers and batch normalization. It is currently unknown if this would actually improve performance for the HipMRI task, however.

Dependencies

The main dependencies for this project are:

- PyTorch 2.4.0 (for Python 3.12 with cuda 11.8 and cudnn9.0)
- pytorch-cuda 11.8
- torchvision 0.19.0
- Numpy 1.26.4
- NiBabel 5.2.1 (in order to read Nifti images)

Note that I have also included a conda environment file called `comp3710_env.yml` that should cover all the required dependencies for you, plus some more. To create a conda environment from a file just use

```
conda env create -f <env_file>
```

Training and Results

Although the current code functions and runs, unfortunately it does not produce great results. The most recent run produced the training loss illustrated in Figure 3, eventually producing a final cross-entropy loss value of around 0.58 over 32 epochs:

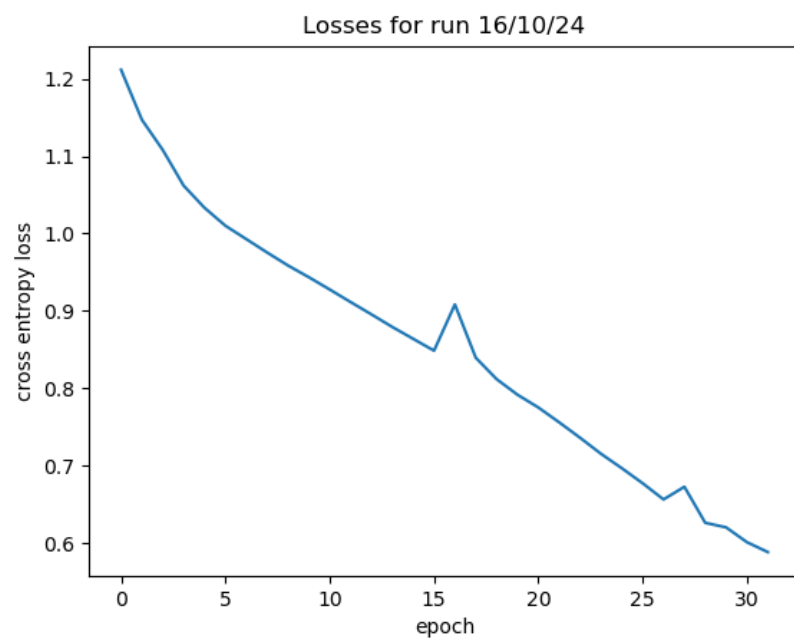
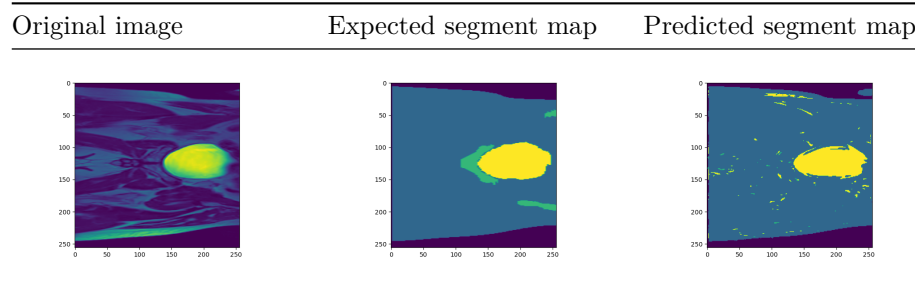


Figure 3: training loss

In addition it also produced segment maps that were not ideal. Below is the result for the first test image of the HipMRI data:



(Note that the code does not extract images as that would blow out my Rangpur disk quota; these were extracted manually by loading up pre-trained model parameters on a lab computer and plotting the results)

The run described above did not include calculating the Dice similarity coefficient, because the code to calculate it was not written at that time. However by manually passing in images and results from a pre-trained model into the Dice code, it produced results of around 0.2 to 0.3, which again is not great.

Perhaps with more time my implementation would produce more accurate segment maps, however due to pressures from other courses (namely STAT3006: Statistical Learning), there was no time to do so.

Author

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References

[1] O. Ronneberger, P. Fischer, and T. Brox, “U-Net: Convolutional Networks for Biomedical Image Segmentation,” in *Medical Image Computing and Computer-Assisted Intervention - MICCAI 2015*, N. Navab, J. Hornegger, W. M. Wells, and A. F. Frangi, Eds., Cham: Springer International Publishing, 2015, pp. 234-241. doi: 10.1007/978-3-319-24574-4_28.

[2] B. Sakboonyara and P. Taeprasartsit, “U-Net and Mean-Shift Histogram for Efficient Liver Segmentation from CT Images,” in *2019 11th International Conference on Knowledge and Smart Technology (KST)*, Jan. 2019, pp. 51-56. doi: 10.1109/KST.2019.8687816.

[3] “pytorch_misc/unet_demo.py at master · ptrblck/pytorch_misc,” GitHub. Accessed: Oct. 15, 2024. [Online]. Available: https://github.com/ptrblck/pytorch_misc/blob/master/unet_demo.py

[4] “Image Segmentation U-Net.” Accessed: Oct. 15, 2024. [Online]. Available: <https://kaggle.com/code/bryanb/image-segmentation-u-net>