Computer Vision and Software Engineering Internship at the Department of Medical Physics, Memorial Sloan Kettering Cancer Center

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Introduction

Memorial Sloan Kettering Cancer Center is home to cutting edge research on the front of Cancer Treatment. Dr. Guang Li, my supervisor, researches on ways to improve medical imaging; better imaging results in better turnaround times for diagnosis and treatment plans, which therefore reduces the treatment times as well! Currently, Dr. Li's research is regarding TR-4DMRI, which is 3D MRI with the fourth dimension of time added. Essentially, Dr. Li is attempting to film a high definition "movie" of a cancer patients body. Due to technological constraints, there isn't an MRI machine capable of just doing this by itself, so we "cheat" this by taking a high resolution static 3D MRI image, and then take a very low resolution 4D MRI and register (i.e. overlay with slight distortion to match portions of similar contrast) the high resolution image onto the low resolution video. While this shows promising results, the algorithm previously struggled with how the organs move up and down during a breathing cycle, yet the spine doesn't - the final product showed the spine moving up and down as well because of this! My job was to develop a tool that would successfully segment (i.e. partition) a 3D image into a body cavity and a body shell. Then, the algorithm would then be performed on the two parts separately to avoid this unintended sliding.

Site Information:

- Department of Medical Physics, Memorial Sloan Kettering
- 1250 1st Avenue, New York, NY 10065
- Dr. Guang Li
- Develop TR4D-MRI
- Develop software to semantically segment 3D MRI images into a body cavity and body shell.
- Issues Confronting Site: GPU available to take Machine Learning route was insufficient, but we made a reasonable prototype!

My workstation in the Department of Medical Physics. The right screen has MATLAB open, where I created most of my code. The left screen is a presentation I was working on for the bi-weekly briefings.

Materials/Methods:

As this was a tech internship, my materials included a desktop computer with two monitors, some softwares and their online resources (MATLAB, Git, Eclipse, VSCode, MIM, Splicer) and a few programming languages (MATLAB, Java, Python). When coding my spine segmentation function, I used both MATLAB and its Image Processing Toolbox and Tensorflow, specifically DeepLab, a Deep Learning Semantic Segmentation framework from Google/MIT. For testing, I had access to a collection of 3DMRI images intended for research, which I would use to test my code against. In order to estimate the accuracy of my functions, I had handmade segmentations created and performed comparisons that determine how close my auto generated segmentation performed (Dice Index, specificity/sensitivity, Jaccard Similarity).
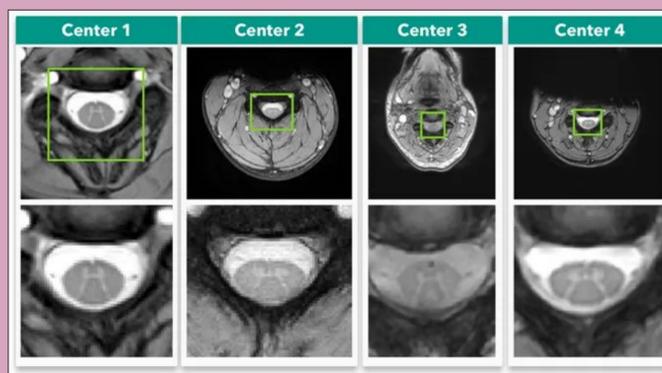
Figure 2: These are T2 MRI images of a human spinal cord in the axial view. Images like these are what I worked with when trying to develop my code. However, my code focused on viewing the body from the coronal view (i.e. from the front). In this view, my code mainly focused on how the spine's vertebrae would form horizontal bars between each other. After using horizontal line detection, I would interpolate these horizontal discs to form a rough "column" that was the spine. From there, it took some refining to completely adjust the image. (image from: nature.com/articles/s41598-018-24304-3)

Figure 3: The image to the right depicts the fully convolutional deep neural network that I used in DeepLab. All forms of machine learning, including Deep Learning, are just a combination of calculus, differential equations and linear algebra. Essentially, an image is converted into a 3D matrix and is multiplied by many more 3D matrices until a final prediction matrix is created. This gives the final predictions of what pixels are exactly which portion. (image from: https://ai.googleblog.com/2018/03/semantic-image-segmentation-with.html
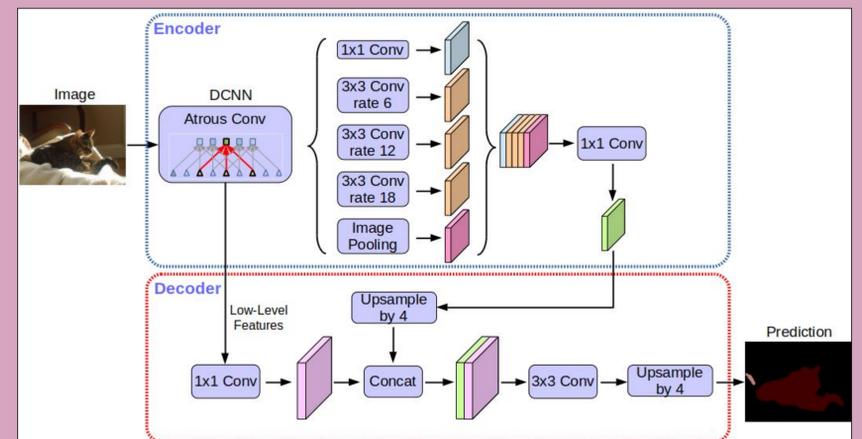
Discussion:

When developing solutions to the problem I was given, I created a solution through MATLAB and through Tensorflow. For my MATLAB segmentation function, I achieved results above a 0.80 Dice index (~.86), which is the recommended value by the American Association of Physicists in Medicine (AAPM). The next step, which was beyond the scope of my project, was to incorporate my software into the current algorithm being used. This is happening right now at MSK! My attempt through Tensorflow was unfortunately cut short due to the fact that we didn't have a machine with a GPU with greater than 8GB (DeepLab V3+ required at least 12 GB). Nonetheless, I was able to produce a prototype with a much more condensed neural network, which could segment 3D MRI images with a 0.74 Dice index. The next step for this would be to gain access to a machine with a better GPU and then attempt to train the official DeepLab V3+ neural network that I attempted to use initially. Based on these preliminary results, it appears that machine learning may be better than MATLAB, since can handle especially robust situations.