**Master of Biomedical Informatics Capstone Project Progress Report**

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**Title of Project: Automatic Segmentation for Biomedical Images: A Deep Learning-Based, Generalizable Semantic Segmenting Tool for MRI and CT**

**Progress Report #: 1**

**Date Submitted: May 7, 2022**

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**Is IRB Approval Required:**  Yes  No

**Date of IRB Application: N/A**

**IRB Number: N/A**

**Work accomplished to-date (200-300 words):**

*Outline all progress completed to-date, detailing any issues that have been encountered with data collection, analysis, writing and IRB approval. Please differentiate clearly between work completed yourself versus work performed by your project mentor and/or your project mentor’s lab members.*

I have explored our datasets which contain 10 subsets from different organs with various image modality (e.g., CT, MRI, multiparametric-MRI). These segmentation tasks are challenging due to complex and heterogenous-located targets, multiple target labels that are unbalanced, and heterogenous appearance [1]. To clarify various complicated steps of this pipeline of preprocessing + segmentation, I have then created a visualization (see Figure 1 below), which should contain all important components/steps mentioned in my proposal [2]. This may be updated as more progress are made, and any modifications are need in the future. Anyways, I will follow this pipeline for each individual segmentation task (i.e., data subset) and finally compare the results of different tasks.

I should have run the preprocessing code provided by my lab to get a better understanding of all the steps. By running the code, we should be able to automatically run the program called 3D Slicer to finish all preprocessing steps for MRI. However, onboarding has been taking unexpectedly long time so that I don’t get access to my lab computer to run this code. We decided to do something else on my local computer for the exploration of CT preprocessing, which has slightly different steps than MRI. Then I wrote some code for CT resampling, cropping, and windowing [3,4]. I also tried manual resampling, cropping, and ROI labeling using 3D Slicer. Results are shown in Figure 2 and 3 below. Bias correction for MRI preprocessing is shown in Figure 4.

**Modifications to original project plan (Bulleted List):**

*If changes have been made/need to be made to your project plan since the time of your project proposal based on oversight feedback, consultation with your project mentor and/or any difficulties mentioned above, please detail these changes.*

* Based on the feasibility and time limit, we decided to first choose two CT and two MRI datasets out the ten (instead of all ten) to work on for my capstone.

**Does the work accomplished so far align with your project proposal timeline?**

Yes  No

**Results**

*Either below or attached, include all results obtained so far during your capstone project.*

**Graphical user interface

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**Figure 1 Preprocessing and Segmentation Pipeline**

Graphical user interface, website

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**Figure 2 Demonstration of CT Windowing**

Figure 2 shows how CT windowing, as known as gray level stretching, works to highlight the desired organs (i.e., spleen and liver), which are also boxed in the figure. Different views of a slice of a 3D CT image are shown respectively. In this case, I picked the window width and window center of grayscale values, which target specific organs/tissues (in this case, spleen and liver), to normalize the intensity of images. The bottom one is windowed for showing bones (e.g., cross-section of spine and rib).

A picture containing indoor

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**Figure 3 Demonstration of Manual Preprocessing using 3D Slicer**

Figure 3 shows each step of manual preprocessing using a software called 3D Slicer. Resampling is used to standardize voxel spacing and image resolution is then changed. In this example, we didn’t see much difference between the original image and the resampled image (voxel space = 1,1,1) but this standardization could be very helpful to the model training later [5].

Graphical user interface, website

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**Figure 4 Demonstration of Bias Correction on Brain MRI**

Figure 4 shows how bias correction works for MRI preprocessing. Bias is a low-frequency signal that corrupts MR images produced by old machines. We may only see subtle difference between original (left) and bias corrected (right) images, where contrast between ROI (e.g., edema in white) and non-ROI (other brain regions) are slightly better. However, this difference is essential to DL algorithms to generate a much better performance.

**Next Steps (Bulleted List):**  *List out the steps you plan to complete before your next submission.*

* Four datasets may be used for model tuning (two CT; two MRI) 🡪 four organs (brain, hippocampus; liver, pancreas).
* Try manual skull stripping using the software -- Robex.
* Run MRI preprocessing (code provided by my lab) on lab computer clusters.
* Explore 3D U-Net.
* CT: Build and tune U-Net models for segmentation of liver and pancreas, respectively.
* MRI: Build and tune U-Net models for segmentation of brain and hippocampus, respectively.

**Journal Selected for Submission: Nature Methods**

**Journal Instructions for Authors Link:**

* [**https://www.nature.com/nature/for-authors/formatting-guide**](https://www.nature.com/nature/for-authors/formatting-guide)
* [**https://www.nature.com/nmeth/submission-guidelines**](https://www.nature.com/nmeth/submission-guidelines)

**References:**

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2. Ronneberger, O., Fischer, P., & Brox, T. (2015). U-Net: Convolutional Networks for Biomedical Image Segmentation. *Lecture Notes in Computer Science*, 234–241. <https://doi.org/10.1007/978-3-319-24574-4_28>
3. Baba, Y. (2021). *Windowing (CT): Radiology reference article*. Radiopaedia Blog RSS. Retrieved April 27, 2022, from <https://radiopaedia.org/articles/windowing-ct?lang=us>
4. Redwankarimsony. (2020, October 7). *CT-scans, DICOM files, windowing explained*. Kaggle. Retrieved May 4, 2022, from <https://www.kaggle.com/code/redwankarimsony/ct-scans-dicom-files-windowing-explained/notebook>
5. *Frequently asked questions*. Frequently Asked Questions - Andy's Brain Book 1.0 documentation. (n.d.). Retrieved March 22, 2022, from <https://andysbrainbook.readthedocs.io/en/latest/FrequentlyAskedQuestions/FrequentlyAskedQuestions.html>