**CS 766 Project Proposal:**

**Automated Segmentation of Bone Marrow on 18F-FDG PET/CT Images**

**Team Members:**

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**Project Website: https://github.com/dthuff/cs766\_qtmi**

**Background**

Oncology patients regularly undergo medical imaging procedures to stage their disease and assess response to therapy. Computed Tomography (CT) scans measure the density of objects in the image, and provide precise anatomical information thanks to their small voxel size. Positron Emission Tomography (PET) scans make use of injected radiopharmaceuticals which target a specific physiological process to create an image which represents the distribution of that physiological process inside the patient. A majority of the PET scans performed use a radiopharmaceutical called 2-deoxy-2-(18F)fluoro-D-glucose (18F-FDG), a glucose analog, to produce a PET image which represents the distribution of glucose utilization in the patient. Because hypermetabolism is a hallmark of many cancers, 18F-FDG PET image values are a useful, noninvasive way to assess cancer. The development of hybrid PET/CT scanners has allowed for the simultaneous acquisition of CT and PET images to become commonplace.

The automated assessment of medical images is appealing for several reasons. First, it can provide a level of objectivity above qualitative scan descriptions often provided by physicians or radiologists. Additionally, reading medical images is a time consuming task, so automated analysis can increase the number of scans a single physician can analyze. This is especially important in countries with developing healthcare infrastructure, where the ratio of patients to experienced physicians may be prohibitively high.

Assessment of bone marrow involvement is important in several cancers which may originate there (myeloma, leukemia), or metastasize to the bone marrow (lymphoma). Management of other non-cancer bone marrow disorders such as anemias may also benefit from automated bone marrow assessment. Additionally, bone marrow is the site of white blood cell production, and so there is interest in characterizing bone marrow uptake as a biomarker indicative of a positive immune response in patients receiving therapies designed to stimulate their immune system.

**Proposal**

The goal of this work will be to develop a tool to automatically segment the bone marrow compartment of clinically acquired 18F-FDG PET/CT scans. Two retrospectively collected datasets will be used to develop this tool. A set of 20 patient scans with no bone marrow disease involvement will be used to develop and assess the performance of the tool for normal bone marrow segmentation. A separate dataset of 8 multiple myeloma patients with a total of 16 18F-FDG PET/CT scans will be used to assess the performance of the tool in patients with diseased marrow. The final product of this work will be a MATLAB script which takes as input a patient CT, PET, and whole-bone mask, and outputs a bone marrow mask.

Work by previous students in our research group have developed related tools that this work will build on. The previous development of a reference skeleton and articulated registration tools will allow for the accurate registration of my scan data to a reference skeleton and the extraction of a whole-bone mask. My tool will take this whole-bone mask, apply it to my PET image data, and make use of a segmentation technique to separate the bone marrow compartment from the hard, outer bone volume.

A similar tool has been developed by our group for use in 18F-FLT PET images, but there is reason to expect new difficulties in translating the tool for use in 18F-FDG PET. 18F-FLT is a marker of cellular proliferation, and since hard bone proliferates much less rapidly than bone marrow, a simple image thresholding technique was adequate to separate marrow from hard bone in that case. 18F-FDG is a less specific radiotracer, as many processes in the body use glucose, so separating marrow from hard bone in this case may be less straightforward. Additionally, the proximity of bones to other, non-bone high uptake structures such as the bladder or kidneys may present challenges. There is also the issue of varying degrees of disease in the marrow which will effect PET image values, and may degrade the performance of the segmentation tool.

To assess the performance of the segmentation tool, I may be able to have an expert physician segment the bone marrow compartment of one or several patients manually, but this is a time consuming task, and may not be possible. I may also be able to access a dataset with both 18F-FDG and 18F-FLT PET scans, in which case the segmentation from the tool developed for 18F-FLT could serve as a ground truth. In either of these scenarios, a voxel-wise ROC AUC, or overlap criteria such as the Dice Coefficient or Jaccard Index would be appropriate performance metrics. Visual inspection of the segmentation can serve as a last-resort performance evaluation.

**Time Table**

February

Write proposal (February 14)

Visually inspect bone/bone marrow 18F-PET image volumes to determine feasibility of segmentation task in both normal and diseased marrow

Perform per-patient registration to reference skeleton, extract whole-bone masks from both PET and CT

March

Experiment with different segmentation methods

Assess impact of disease involvement, skeletal location, other factors on segmentation performance

Prepare mid-point report (April 2)

April

Finalize segmentation tool, run segmentation on all patient scans, assess tool performance

Prepare presentation and final report (April 23, May 7)