Group 5
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Project: Radiotherapy Dose-Toxicity Analysis User Interface

Goal: Design and implement a web-based user interface for rendering 3D objects, segmenting 3D shapes, and performing dose-toxicity analysis on 3D objects.

Medical Background/Relevance:

Physicians lack a simple method to quantitatively analyze dose distributions within organs before, during and after treatment. A user interface with 3D rendering would allow physicians to better analyze dose distributions before treatment, and make necessary adjustments to the treatment plan. Currently, there exist no simple tools for clinicians or researchers for extracting and analyzing dosage features of treatment plans.

Technical Approach:

We will first obtain access to an existing python codebase which handles database access and feature analysis. Then, we will bridge the front end - client side is written in javascript - to the back end, server side python codebase. In order to connect the UI coded in javascript, to the python codebase, we will use a python web framework, web.py, to allow us to write python programs that use the local machine as a server. We can then send information between the javascript and python codebase using xhr http requests. Currently, we have completed these steps of the project, and we can call functions in the python codebase from the user interface, and send “dummy” information back and forth.

Next, we will design a simple user interface which includes scroll down menus and a 3D visualization panel. We will render 3D objects using d3.js, a javascript library for dynamically rendering 3D data in web browsers. Currently, we have completed these steps of the project. Next, we will collect user input via scroll down menus, call python functions, and display 3D data in order to complete our initial, rudimentary UI.

Next, we will implement segmentation tools into our UI. Segmentation tools include 2 aspects. First, we will integrate existing segmentation scripts, written in python, into the UI. Second, we will develop simple, interactive segmentation tools into the UI. This will include cutting planes, which will split the object into regions. These regions can be passed to the python codebase for analysis, and the results returned to the user interface. This will satisfy our expected deliverables. We will then implement

draggable cutting planes, and radial cutting planes. Then, we will implement additional analysis in python for extracting dose features such as entropy and symmetry.

Finally, we will document every stage of the process. This is included in our deliverables. Documentation will be available for changing the user interface and incorporating new analysis scripts.

Deliverables

Minimum: A UI for cutting and analyzing 3D objects in planes using manual input and existing analysis scripts.

Expected: A UI for cutting and analyzing 3D objects in planes and additional cutting features using manual input. A few additional analysis scripts are integrated into UI, future analysis scripts can be easily added. Documentation for running the UI and adding additional analysis scripts.

Maximum: An interactive UI for cutting and analyzing 3D objects with draggable planes and additional cutting features. UI has additional features for regional analysis, and future analysis scripts can be easily added. Additional feature list can be used for machine learning analysis. Documentation for running the UI and adding additional analysis scripts.

Timeline and Milestones

All code created will be thoroughly commented and documented.

Objective	End Date	Measureable
Familiarity with code and database	2/20 (done)	Ability to run website and use existing analysis
Reading existing documentation, choosing visualization library	2/22 (done)	Displaying 3D points
Connecting local data fetching with primitive website UI. Document process for connecting front end to back end.	3/1 (in progress)	Interactive drop down menus that display basic lists of data.
Static 3D visualization of Data	3/6 (in progress)	Interactive drop down menus that display images and graphs of data.
Section regions of interest using existing masks	3/15	Dose-volume histograms of subsections of organs
Section regions using basic plane interfaces	3/27	Documented instructions on how to create planes for

		segmentation
Add ability to drag planes in 3D space, use these to segment data	4/13	Documented instructions on how to interact with object in 3D space.
Add customizable masks for segmentation. Document instructions for making custom masks.	4/27	Documented instructions showing how to make custom masks.
Final Presentation	5/11	Full demonstration of the capabilities of the user interface

Dependencies

Dependency	Plan to resolve	Resolution Date
Access to database	Pranav and Dr. McNutt are emailing IT	2/13 - completed
Access to Pranav's code	Meet with Pranav	2/13. Weekly meetings with Pranav - completed
Availability of radiologists for feedback	Coordinate with Dr. McNutt, he can be our first tester	Tuesday 4:30 meetings with Dr. McNutt and Dr. Taylor

Management Plan

- Weekly meetings with Pranav and Dr. McNutt - 4:30 on Tuesday and additional meetings with Pranav as needed
- Alex - Front end development with Javascript
- Willie and Santiago - Integrating front end with python back end; developing additional analysis tools in python

Reading List

- Lakshminarayanan, P. (2017). Radio-morphology: Parametric Shape-Based Features in Radiotherapy (Unpublished master's thesis). Johns Hopkins University.
- McNutt, T., PhD., & Lakshminarayanan, P. (2018, February 6). User Interface to Extract radio-morphologic features for refined dose-toxicity analysis in radiotherapy. Lecture presented at CIS II Lecture in Hackerman B17, Baltimore, MD.

- Chen R, Gabriel P, Kavanagh B, McNutt T, “How will big data impact clinical decision making and precision medicine in radiation therapy?” Int’l J. of Radiation Oncology, Biology, Physics. Published online: November 27 2015
- Jacques R, Wong J, Taylor R, McNutt T. "Real-time dose computation: GPU-accelerated source modeling and superposition/convolution." Med Phys. 2011 Jan;38(1):294-305.
- Ricchetti F, Wu B, McNutt T, Wong J, Forastiere A, Marur S, Starmer H, Sanguineti G. "Volumetric change of selected organs at risk during IMRT for oropharyngeal cancer." Int J Radiat Oncol Biol Phys. 2011 May 1;80(1):161-8. doi: 10.1016/j.ijrobp.2010.01.071. Epub 2010 Nov 19.