Radiotherapy
Dose-Toxicity Analysis UI

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Mentors: Dr. Todd McNutt, Pranav Lakshminarayanan
Goal

Develop a web-based user interface for refined dose-toxicity analysis:

- Compatible with existing online SQL database for obtaining the medically related data
- Create interactive 3D visualizations of objects using JavaScript libraries such as D3.js
- Allow physician to easily use segmenting tools on organs, run analysis on new regions
- **Display the results** using interactive DVH histograms on the website
- Allow new feature analysis scripts to be **easily added** to the existing user interface
- Enable the users to **Download** the results of the analyses from the web
Significance

- Researchers and oncologists lack an easy to use way to analyze Radiation Therapy Dose-Volume data.
- This web application would allow researchers not experienced with programming or a command line interface to:
  - Visualize dose-volume data
  - Segment the Regions of Interest (ROIs) using several preset masks
  - Segment the ROIs with customizable masks
  - **Run dose-volume analysis on segmented ROIs**
  - Export dose-volume data for further analysis
## Resolved Dependencies

<table>
<thead>
<tr>
<th>Dependency</th>
<th>Plan to resolve</th>
<th>Resolution Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access to database</td>
<td>Pranav and Dr. McNutt are emailing IT</td>
<td>2/13</td>
</tr>
<tr>
<td>Access to Existing DVH analysis code</td>
<td>Meet with Pranav</td>
<td>2/13</td>
</tr>
<tr>
<td>Access to Pranav’s segmentation Code</td>
<td>Meet with Pranav</td>
<td>3/7</td>
</tr>
</tbody>
</table>
Previous 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.

**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.
Updated Deliverables

**Minimum:** A UI for visualizing organs in 3D, calculating DVH curves, and running python analysis scripts from the javascript layer. Documenting our work.

**Expected:** A UI for segmenting and analyzing organs in 3D using a list of segmentation options. Dose-volume data analysis scripts are integrated and can be performed on segments of organs. Results of the analyses can be exported, provide code documentation.

**Maximum:** An interactive UI for segmenting and analyzing organs in 3D with a flexible segmentation as indicated by the user in addition to the existing ones. Dose-volume data analysis scripts are integrated and can be performed on segments of organs. An interactive table that can summarize the DVH analysis data.
Technical Approach

1. Set up **Python** Web Framework on the **back-end** side
2. Set up the **front end** visualizations
   a. **Chosen** Library, for the select drop downs
   b. D3 library for **DVH** curves and object 3D visualization
   c. Include options, and later on text boxes enabling user to segment data
   d. **DataTable** containing information plotted in the DVH curves
3. Enabling **communication** between back and front end using XHR requests
4. Enabling the user to **download** the results of the analyses
Back end

- Access to python segmentation and analysis tools
- Web.py for setting up python web framework
- Server runs on local machine
We used **Chosen** library for the select boxes, to allow for multiple choices.

To display the organ, we used an interactive 3d object, created by **d3.js** library. It requires d3 4th version.

To display the DVH curve, we use an interactive scatter plot, also created by d3.js library. It requires d3 3rd version.
Problem: Each of our plot used a different version of d3 library. Both are on the same page, and HTML does not allow both version (2nd one overwrites first one).

Initial Try? Make one of the plots adaptable to the other version of d3 code. This did **not work**, as they used different zooming and dragging mechanisms, and for it to be compatible, we needed to recalculate the coordinates.

Solution? Used *iframe*: a nested browsing: embedding another HTML into the current page, created **2 separate** HTML files, 1 for each plot.
Merging Front and Back End

- XHR requests from JS front end to specific urls
- For given ROI, return DVH and ROI point cloud data in JSON format for analysis and 3D visualizations

Front End JS

```javascript
var dose = $(selectid3).chosen().val();
var roi = $(selectid4).chosen().val();
xhr = new XMLHttpRequest();
xhr.open('GET', 'http://127.0.0.1:8080/getdvh?dose=' + dose + '&roi=' + roi);
xhr.onreadystatechange = function() {
    if(xhr.readyState == 4 && xhr.status == 200) {
        var dvh = JSON.parse(xhr.responseText);
        dvh_data = [dvh.prob, dvh.dose];
    }
}
xhr.send();
```

Back End Python

```python
def GET(self):
    urls = ("/", "index",
            "/get_rois", "get_rois",
            "/getp", "getp",
            "/getd", "getd",
            "/getdvh", "getdvh",
            "/getvol", "getvol")
    return json.dumps(dvh)
```
## Updated Timeline

<table>
<thead>
<tr>
<th>Activity</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
</tr>
</thead>
<tbody>
<tr>
<td>Getting Familiar with existing code and SQL database</td>
<td>Feb 12 - Feb 16</td>
<td>Mar 5 - Mar 9</td>
<td>Apr 2 - Apr 6</td>
<td>May 7 - May 11</td>
</tr>
<tr>
<td>Basic website framework</td>
<td>Feb 19 - Feb 23</td>
<td>Mar 12 - Mar 23</td>
<td>Apr 9 - Apr 13</td>
<td>May 11 - May 16</td>
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<tr>
<td>Choosing Js Library</td>
<td>Feb 26 - Mar 2</td>
<td>Mar 19 - Mar 30</td>
<td>Apr 16 - Apr 20</td>
<td>May 16 - May 21</td>
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<tr>
<td>Documentation of code and Instructions</td>
<td>Mar 5 - Mar 9</td>
<td>Mar 26 - Mar 30</td>
<td>Apr 23 - Apr 27</td>
<td>May 21 - May 27</td>
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<tr>
<td>Basic UI with DVH</td>
<td>Mar 12 - Mar 16</td>
<td>Apr 2 - Apr 6</td>
<td>Apr 30 - May 4</td>
<td>May 21 - May 27</td>
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<tr>
<td>Exporting Data</td>
<td>Mar 19 - Mar 23</td>
<td>Apr 9 - Apr 13</td>
<td>May 7 - May 11</td>
<td>May 7 - May 11</td>
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<tr>
<td>Interact with 3D visual representation of ROIs</td>
<td>Mar 26 - Mar 30</td>
<td>Apr 16 - Apr 20</td>
<td>May 11 - May 16</td>
<td>May 21 - May 27</td>
</tr>
<tr>
<td>Integrate user interface with existing tools</td>
<td>Apr 2 - Apr 6</td>
<td>Apr 23 - Apr 27</td>
<td>May 7 - May 11</td>
<td>May 7 - May 11</td>
</tr>
<tr>
<td>Add Customizable segmentation tools</td>
<td>Apr 9 - Apr 13</td>
<td>May 30 - May 4</td>
<td>May 7 - May 11</td>
<td>May 7 - May 11</td>
</tr>
<tr>
<td>Interact and search data on table</td>
<td>Apr 16 - Apr 20</td>
<td>May 4 - May 11</td>
<td>May 7 - May 11</td>
<td>May 7 - May 11</td>
</tr>
<tr>
<td>Milestone</td>
<td>Date - End</td>
<td>Status</td>
<td>Measureable</td>
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<tr>
<td>-----------------------------------------------</td>
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<td>-----------------------------------------------------------------------------</td>
<td></td>
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<tr>
<td>Familiarity with code and database</td>
<td>2/20</td>
<td>Completed</td>
<td>Run the basic analysis notebooks</td>
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<tr>
<td>Basic website framework</td>
<td>2/27</td>
<td>Completed</td>
<td>See patient ROIs and ID numbers on website</td>
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</tr>
<tr>
<td>Choose Js Library</td>
<td>2/27</td>
<td>Completed</td>
<td>Successfully visualize sample data</td>
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<tr>
<td>Basic UI with DVH</td>
<td>3/15</td>
<td>Completed</td>
<td>Display DVH for any selected patient anatomy</td>
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<tr>
<td>Exporting Data</td>
<td>3/27</td>
<td>Completed</td>
<td>Download DVH data as .csv file</td>
<td></td>
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<tr>
<td>Interact with 3D visual representation of ROIs</td>
<td>4/1</td>
<td>Ongoing</td>
<td>Segment objects that are compatible with analysis scripts</td>
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<tr>
<td>Integrate user interface with existing tools</td>
<td>4/10</td>
<td>Ongoing</td>
<td>Get matching results to command line analysis</td>
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<tr>
<td>Add table, customizable segmentation tools</td>
<td>4/25</td>
<td>Not Started</td>
<td>Segment objects by moving planes in 3D representation of ROIs, search data with table</td>
<td></td>
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</tbody>
</table>
Extra Slides
Management Plan

- Weekly **meetings** with Pranav and/or Dr. McNutt
- **Alex** -
  - 3D rendering,
  - JavaScript and Front-end Rendering
  - Data Visualization, Interactivity Management
- **Willie and Santi** -
  - Focus on passing data between JavaScript, Python and SQL;
  - Adding new modules to front end and integrating with back end
  - Back-end Management
Reading List

- 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