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## Development of visualization tools for 4D CT datasets

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# Visualization of Tumors in 4D Medical CT Datasets

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## Objective

Develop a set of tools to effectively visualize, measure, and annotate 4D (3D + time) Computed Tomography (CT) images of radiation oncology patients for both research and clinical applications.

Currently, radiotherapy treatment planning utilizes a 2D perspective of 4D data, thereby reducing the amount of information visually available. This information, such as the shape, movement and location of a tumor is critical in treatment planning.

These tools are designed to both improve a user's perspective and analysis of tumor shape, motion, and location during respiration. Furthermore, measurement and annotation tools are designed to give users the ability to validate and report findings within visualizations.

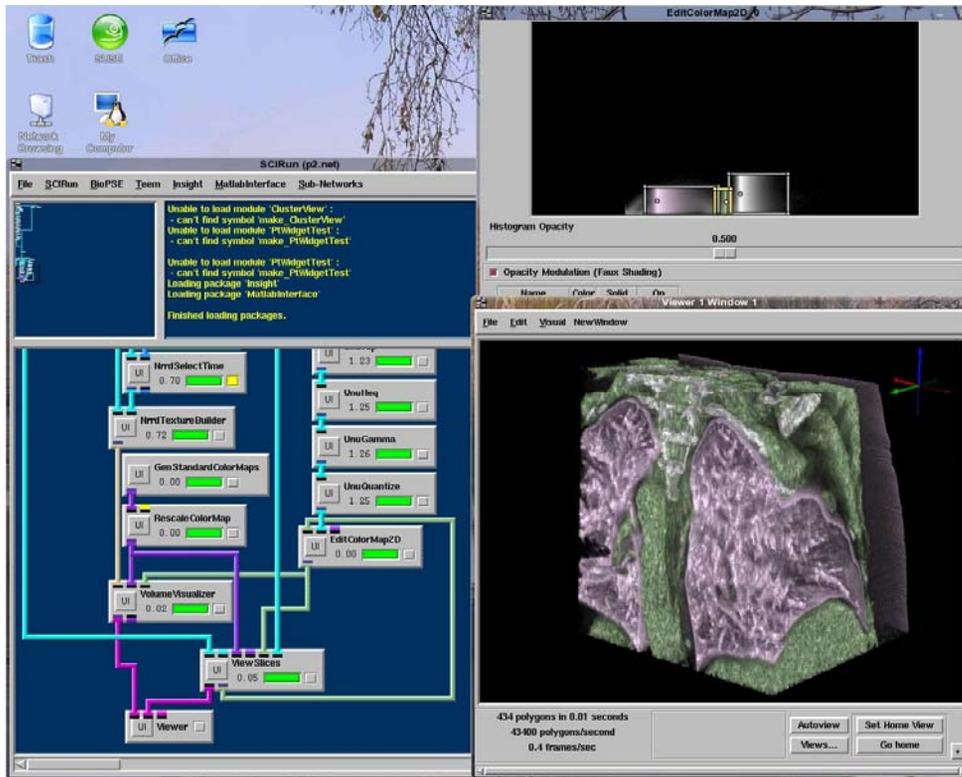
## SCIRun

SCIRun is a Program Solving Environment, developed by the scientific computing and imaging institute researchers at the University of Utah, that creates simulations, models and visualizes scientific problems. SCIRun is a visual programming development environment that uses numerous programs called "modules" that, when inter-connected, create a larger, more robust program.

By designing programs through interconnecting modules, this makes each module independent of each other, allowing them to be interchangeable between applications.

Figure 1

Screenshot of a SCIRun Network (left) and 2D histogram (top right) built to show the visualization (bottom right).



## Visualization: Data Validation

Visualized data needs to be verified for geometric accuracy before it can be used for applications such as treatment planning.

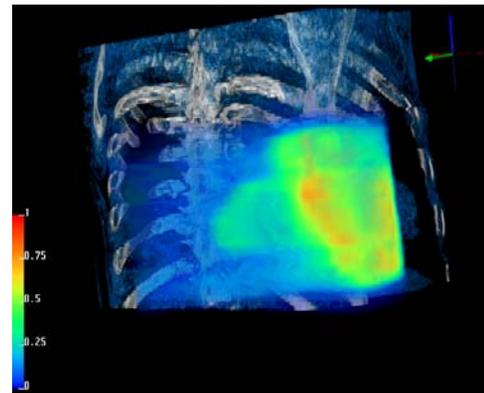
Basic measurement capabilities in 3-dimensions and the ability to record these measurements for future reference provide fundamental validation tools.

CT data is visualized in three different perspectives: Axial (top to bottom), Saggital (left to right) and Coronal (front to back). Measurement markers can be moved in any of these perspectives providing flexible user interaction.

Experimentation can be done on non-human subjects to verify the accuracy of these tools.

Figure 2

Example of a treatment dosage visualization superimposed on a volume visualization of the corresponding patient.



## Summary

Tools are being developed that allow physicians to rapidly segment and identify regions of interest in 3 or 4-dimensions. This would be a major advancement over the current methods that approach this process one 2D subset of the 4D information at a time.

The total time for treatment planning preparation can be reduced by allowing more efficient analysis of size, shape, and movement of tumors. This can improve the overall effectiveness of a treatment center by increasing the number of patients treatable in a given amount of time.

Treatment planning can be done more accurately. Visualizing 3-dimensional information 2-dimensions at a time can be difficult enough without doing so over the 4th dimension of time. Visually representing the full set of information at once can free a physician's thoughts for more treatment-oriented concerns.

## Approach

The base source code is written in C++ using OpenGL for graphics visualization, TCL/TK for the GUI and GLUT to control keyboard input. Tools are developed as add-ons that provide additional functionality to this existing scientific platform. Individual modules are a combination of:

- C++ for data input/output control and algorithm implementation
- XML for data input/output characterization and general documentation
- TCL/TK for graphical user interface (GUI).

## Visualization: Treatment Tools

Current work is focused on development of tools that can utilize the inherent advantages of 4D visualization for treatment of patients. One such tool, not pictured here but an extension of an existing 2D concept, is a way to measure radiological pathlength from unconventional angles.

Figure 2 shows an example of past work, a radiation dosage visualization that allows a doctor to see the dose distribution of a previous treatment.

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