Tomographic Patient Registration & Conformal Avoidance Tomotherapy

Jennifer Stacy Aldridge

Under the supervision of Professor T. Rockwell Mackie

At the University of Wisconsin-Madison

Development of tomotherapy has led to the emergence of several processes, providing the basis for many unique investigative opportunities. These processes include setup verification, tomographic verification, megavoltage dose reconstruction, and conformal avoidance tomotherapy. Setup verification and conformal avoidance tomotherapy, in particular, are two closely intertwined matters. In order to avoid critical structures located within or adjacent to indistinct tumor regions, accurate patient positioning from fraction to fraction must be ensured.

With tomographic patient registration, a higher level of assurance is offered than with traditional positioning methods. Translational and rotational offsets are calculated directly from projection data using cross-correlation or fast Fourier transforms. Experiments assessing the algorithm's ability to calculate individual offsets were conducted using the University of Wisconsin's Tomotherapy Benchtop. These experiments indicate statistical errors within ± 1 mm for offsets up to approximately 20 mm, with maximum offset errors of about ± 2 mm for displacements up to 35 mm. The angular offset compo-

nent is within $\pm 2°$. To evaluate the registration process as a whole, experimental results from a few multi-parameter examples are also analyzed.

With the development of tomographic patient registration in projection space, efforts to promote further sparing of critical structures are justified. Conformal avoidance tomotherapy has as its objective to treat an indistinct tumor region while conformally avoiding any normal critical structures in that region. To demonstrate the advantages of conformal avoidance tomotherapy, conventional and tomotherapy treatments are contrasted for both nasopharyngeal and breast carcinoma cases.

For initial research efforts, computed tomography data sets of a human male and female were obtained via the "Visible Human Project". Since these data sets are on the order of hundreds of megabytes, both the size and complexity of the database was reduced. Production of these smaller data sets has presented a unique opportunity to establish a standard human CT slice library for research in radiation therapy. A brief history of the original data sets is included, as well as details of the reduction process, radiotherapy applications, and information on accessing these reduced image files.