MEGAVOLTAGE COMPUTED TOMOGRAPHY FOR TOMOTHERAPEUTIC VERIFICATION

Kenneth Ruchala
Under the supervision of Professor Thomas R. Mackie

A system for delivering highly conformal radiation therapy treatments is being developed at the University of Wisconsin, Madison. This system is called tomotherapy, because it is capable of delivering radiation in temporally-modulated slices. However, improvements in delivery capability are limited if not accompanied by comparable improvements in treatment verification. That is, the ability to precisely control radiation delivery is most advantageous when one has precise knowledge of a patient's position and anatomy. To this end, megavoltage computed tomography (MVCT) has been investigated through the addition of a megavoltage detector to a tomotherapy research system. This allows the megavoltage linear accelerator to be used not only for conformal radiotherapy delivery, but also for tomographic imaging.

A theoretical analysis demonstrates that MVCT is necessarily inferior to kilovoltage computed tomography (kVCT) for typical patient scans, due primarily to the reduced number of imaging photons and the lower contrast per photon. On the other hand, resolution is potentially comparable to kVCT for high-contrast objects. The significance is that MVCT may be able to verify radiotherapy treatments, while avoiding the cost and complexity of adding kVCT functionality. Through the development of the Tomotherapy Benchtop, these results are demonstrated experimentally. Specifically, 2.5 cm objects with contrasts below 1% can be seen using 7 cGy MVCT, and resolutions are better than 1.25 mm for air holes. In addition, the reconstructed values using MVCT can be more robust than for kVCT.

The possibilities for reconstructing treatment data have also been investigated. That is, one method of performing MVCT is to operate analogously to kVCT, with a full field-of-view, and no intensity modulation. This allows patient images to be collected immediately before or after the treatment. Yet, it is also possible to use the treatment data in conjunction with the reconstruction process. This allows for improvements in image contrast while reducing patient imaging dose. Moreover, patient throughput can be increased by collecting all of the data necessary for reconstruction during the treatment itself.