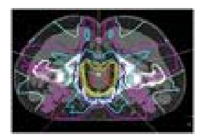
RESEARCH

Mar 12, 2007

Streamlined thinking on IMRT planning

The development roadmap for radiation therapy is directed by one overriding priority: the realization of treatment systems that deliver a large dose to the tumour while for the most part sparing healthy, radiation-sensitive tissues. Intensity-modulated radiation therapy (IMRT) is a case in point. This computer-controlled method uses a multileaf collimator with around 80 moving fingers to "paint" radiation on the region of interest. On the plus side, IMRT yields precise irradiation of targets with complex 3D shapes; the downside is that it can require hours of manual "tuning" to determine an effective treatment plan for a given patient.

Now, however, Richard Radke and colleagues at Rensselaer Polytechnic Institute (Troy, NY) and the Memorial Sloan-Kettering Cancer Center (New York) have come up with a machine-learning algorithm that has the potential to determine acceptable IMRT plans automatically in a matter of minutes, and without compromising treatment quality (*Phys. Med. Biol.* **52** 849).



A simpler plan

The IMRT planning process typically involves dividing each radiation beam into subcomponent pencil beams ("beamlets"). The physicist then applies numerical optimization algorithms to determine the beamlet intensities, such that the resultant radiation dose distribution best matches the requirements specified by the physician. The clinical goals of planning are encapsulated in an objective function that assigns a numerical score to each plan.

"A basic difficulty is the formulation of this objective function," note Radke and colleagues in *Phys. Med. Biol.* What they're referring to is the fact that IMRT planners typically have to make compromises between competing clinical objectives – for example, delivering as high and as uniform a dose as possible to the planning target volume, while sparing organs at risk and normal tissues as much as possible.

The trouble is, the compromise in any given case is not easy to specify in terms of the parameters (dose limits, weights, importance factors, etc) that define the objective function. Equally, the parameter values differ from case to case. "In current implementations of IMRT," explain the researchers, "prior knowledge of these parameters is not available, and planners can spend a substantial amount of time adjusting parameters in order to get a clinically acceptable plan."

Beat the clock

Despite improvements in numerical optimization procedures, the start-to-finish inverse-planning process of obtaining a clinically acceptable IMRT plan for a difficult site can take several hours – typically up to about four hours for prostate cancer and up to an entire day for more complicated cancers in the head and neck, according to Radke. That's largely down to the manual trial-and-error process of adjusting parameters in the objective function.

"A systematic and partly automated methodology would reduce the time wasted in exploring unfruitful parameter sets and aid in reaching the desired planning goals efficiently," say the researchers.

With this in mind, Radke and colleagues first performed a sensitivity analysis, which showed that many of the parameters could be eliminated completely because they had little effect on the outcome of the treatment. They then showed that an automatic search over the smaller set of sensitive parameters could theoretically lead to clinically acceptable plans.

The procedure was put to the test in experiments that required the development of radiation plans for 10 patients with prostate cancer. In all 10 cases the process took 5–10 min. Four cases would have been immediately acceptable in the clinic; three needed only minor "tweaking" by an expert to achieve an acceptable radiation plan; and three would have demanded more attention from a radiation planner.

Radke and his coworkers now plan to develop a more robust prototype that can be installed on hospital computers and evaluated in a clinical setting. "Our methods can be applied to anatomically similar situations, such as prostate treatments intended for different total doses, using more treatment beams, or subject to different clinical preferences," writes the New York team in *Phys. Med. Biol.* Radke also believes the new approach has the potential to improve efficiency for sites where the IMRT planning process is more challenging or tedious, such as head-and-neck cancer treatment.

In a related project, Radke is collaborating with colleagues at Massachusetts General Hospital (Boston, MA) to create computer vision algorithms that offer accurate estimates of the locations of tumours. This automatic modelling and segmentation process could help radiation planning at an earlier stage by automatically outlining organs of interest in each image of a CT scan.

The Rensselaer research is supported by the US National Cancer Institute and the Center for Subsurface Sensing and Imaging Systems (CenSSIS) at Rensselaer, which is funded by the National Science Foundation. Renzhi Lu, a graduate student in electrical engineering at Rensselaer, also contributed to the research.

About the author
Joe McEntee is Editor of *medicalphysicsweb*.

Further reading
R Lu *et al*. 2007 Reduced-order parameter optimization for simplifying prostate IMRT planning *Phys. Med. Biol.* **52** 849.

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