Quality assessment for radiotherapy treatment planning using data envelopment analysis

Matthias Ehrgott[*], Kuan-Min Lin[*], Andrew Macann[**], Juliane Manitz[+], Wan Fariza Paizi[++], Andrea Raith[++], Paul Rouse[^], Giuseppe Sasso, John Simpson[^^]**

***Management School, Lancaster University, UK; [**]Auckland City Hospital, New Zealand; [+]Chairs of Statistics and Econometrics, University of Goettingen, Germany; [++]Department of Engineering Science, University of Auckland, New Zealand; [^]Department of Accounting and Finance, University of Auckland, New Zealand; [^^]Calvary Mater, Newcastle, Australia**

Radiotherapy treatment is a prominent and successful treatment approach for cancer [1]. The aim of radiotherapy treatment is to damage the tumour by irradiating it to harm its cells while avoiding damage to surrounding healthy tissue, and most importantly critical organs. Radiotherapy treatment technology has evolved significantly over the last decades. Technological advances increase the ability to conform radiation to the tumour planning target volume (PTV) whilst minimising dose to adjacent avoidance structures (organs at risk (OAR)). As the ability to accurately deliver complex dose distributions has become a reality, the emphasis has shifted to treatment plan quality in order to maximize the gains afforded by this technology.

Radiotherapy treatment planning involves assessment of several objectives related either to the PTV or OARs. The major commercial treatment planning systems use a ‘weighted sum of the constituent objectives’ technique in deriving the treatment plan. Once the plan is calculated, it is iteratively modified by a planner by adjusting the relative importance (weights) of one or more of the objectives until all or most of the desired plan criteria are met. A majority of commercial radiotherapy treatment planning systems requires planners to iteratively adjust plan parameters in order to find a satisfactory plan. This iterative trial-and-error nature of radiotherapy treatment planning results in an inefficient planning process. At the completion of the planning phase, a plan is produced for the oncologist to review. If the plan is deemed to be suboptimal it takes more time to produce another plan, without knowing in advance whether the new plan will be superior to the previous plan. Assessing treatment plan quality is a topic that is receiving attention by researchers and health practitioners [2-4].

We propose to assess treatment plan quality using Data Envelopment Analysis (DEA) [5] by comparing each new plan being generated to existing plans. This is not straight-forward as every patient is different, the tumour (PTV) and OARs will have different shapes in each case, and the relative closeness to organs at risk will vary. DEA allows benchmarking of quality parameters such as dose delivered to the tumour and dose received by OARs while taking into account patient specific variations.

We demonstrate that DEA-based plan assessment works well for prostate cancer cases [5] which have one main OAR, the rectum, with a patient dependent volume of OAR overlap with the PTV. In addition to considering OAR sparing given patient geometry [2-4], our approach [5] is capable of simultaneously considering dose delivered to the tumour. What sets our on-going research apart from other approaches is that the DEA methodology is able to capture several treatment quality parameters such as dose received by both OARs and tumour (PTV), as well as the geometric relationship between them.

A database of over 200 patients was built as part of the Trans Tasman Radiation Oncology Group (TROG 07.03) RadioHUM trial which was a mucositis intervention study [6,7]. We analyse a subset of this dataset with a view of identifying the most crucial plan parameters (in terms of treatment outcomes) and treatment severity descriptors to use in the DEA analysis of these cases.

Ultimately we envision use of DEA-assisted quality assessment in radiation therapy planning: As the planner produces different plans in the trial-and-error process of treatment planning, they can be automatically assessed by DEA-based comparison to similar existing plans. This gives an indication of plan quality on-the-fly, as part of the planning process either indicating a plan is close to what is historically known as an optimal plan, or gives an indication of aspects that should be improved.

Submission category: Academic

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