Master's Thesis Engineering Technology

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Reduction of pre-treatment QA for intensity modulated treatments using a complexity threshold

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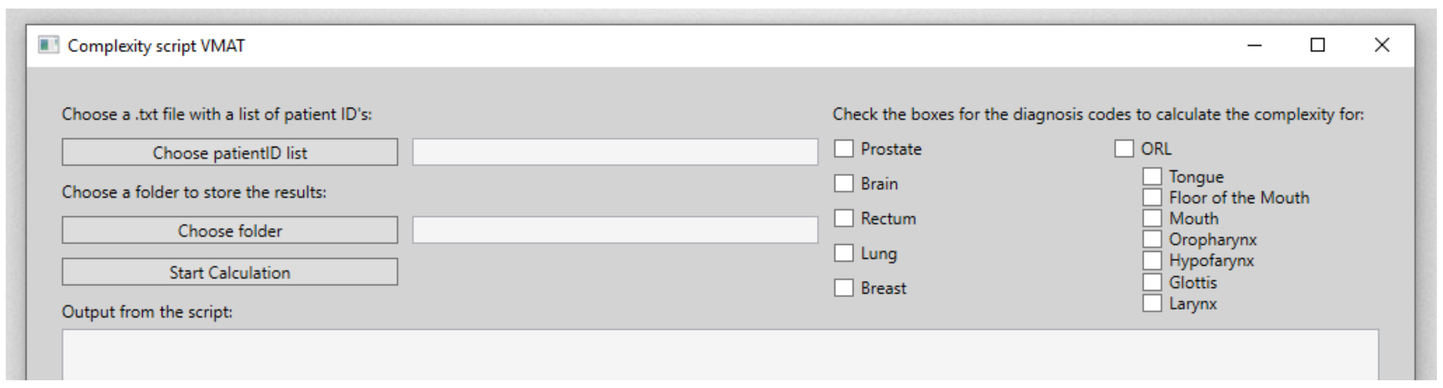
Introduction

This thesis researches the possibility to reduce the amount of patient specific pre-treatment QA that has to be performed for intensity modulated radiotherapy, by calculating the complexity of the irradiation plan. Currently the deliverability of each irradiation plan is verified on the linac before the first treatment of a patient. The complexity metric will be used to try and predict the outcome of that QA verification.

Method

A computational script was developed to calculate the complexity of the irradiation plans. This can be used as a plug-in in Eclipse during the treatment planning, or as a standalone to perform an analysis on multiple patients.

The six most prevalent treatment sites were examined by calculating the average complexity for their respective irradiation plans, A retrospective study was conducted to compare gamma passing rates of previously planned irradiations with the complexity calculated with the Edge Metric (EM) based on correlation and ROC-curves.



Results

It was shown that there is a positive linear correlation between the edge and the amount of monitor units that was used to deliver the plan to the patient. A difference in results when using an absolute or relative method to generate gamma passing rates was ascertained. With the relative method delivering the best results for this research.

Thresholds were proposed at 0.18 mm^{-1} and 0.19 mm^{-1} for which it is better to adjust or replan a treatment when the complexity is above this threshold. This is for the prostate VMAT arcs delivered with a Clinac at the Limburgs Oncologisch Centrum (LOC).

Based on the average complexity of irradiation plans, different categories were determined for which the analysis of the complexity metric should be split up:

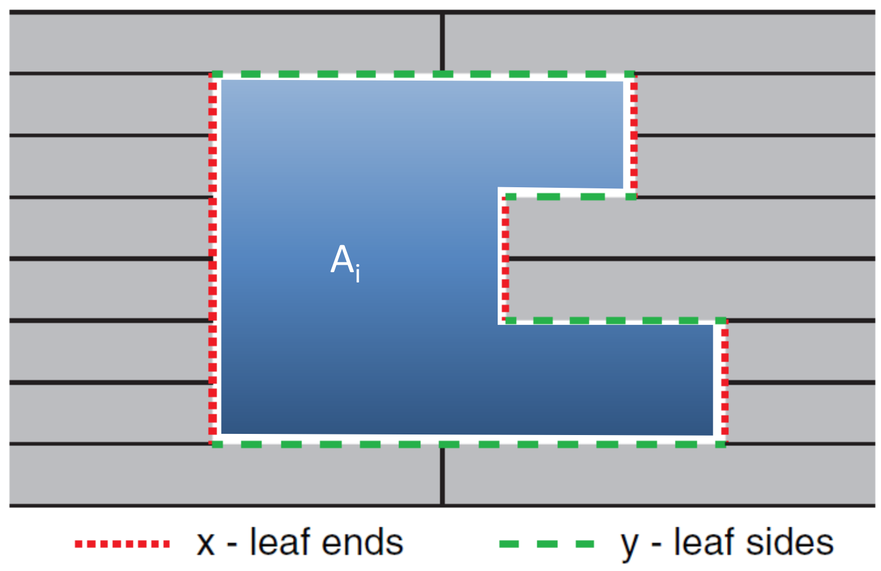
- treatment sites,
- treatment units,
- treatment methods.

Calculating the complexity

$$\mathrm{EM} = \frac{1}{MU}\sum_{i=1}^{N} MU_i \times \frac{y_i}{A_i}$$

y_i = Sum of open leaf side
A_i = Total aperture per control point
MU_i = MU's per control point
N = Total number of control points
MU = Total amount of plan MU's

This results in values between 0 (low complexity) and 1 (high complexity). [1][2]



Discussion & further research

To get a better view on the impact this can have on the workflow, the retrospective study should be performed for the different groups that were determined.

It is also important to note that this research is specific to one treatment centre (LOC). Other treatment centres that want to implement this should do the retrospective study for the treatment plans and gamma tests from their centre.

Scripts that can write to the database are an interesting tool to facilitate this research. This would allow researchers to gather different gamma passing rates automatically without having to look up different passing rates manually.

Supervisors / Cosupervisors:

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[1] K. C. Younge, M. M. Matuszak, J. M. Moran, a. D. L. McShan, B. A. Fraass en D. A. Roberts, „Penalization of aperture complexity in inversely planned volumetric modulated arc therapy", Medical Physics, vol. 39, nr. 11, pp. 7160-7170, 2012.

[2] K. C. Younge, D. Roberts, L. A. Janes, C. Anderson, J. M. Moran, en M. M. Matuszak, "Predicting deliverability of volumetric-modulated arc therapy (VMAT) plans using aperture complexity analysis", *J. Appl. Clin. Med. Phys.*, vol. 17, nr. 4, pp. 124–131, 2016, doi: 10.1120/jacmp.v17i4.6241.

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