Creation and Validation of An Interactive Electron Cutout Library

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INTRODUCTION

Electron treatments often require custom blocks for each patient. Blocks may be purchased from a fabricator, often used once and returned to the vendor or discarded. By designing a software tool to enable cataloguing and matching of existing electron cutouts, reutilization of existing blocks is possible. This software will integrate with the treatment planning process and provide verification for new electron block plans against a reference library. Once a match is determined, the dosimetrist will have the ability to view the most similar existing blocks and determine if the new electron block can be replaced with an existing in house electron block.

This will reduce costs associated with fabricating a new block for every new field while increasing the speed at which patients can begin treatment. This trend will increase in utilization as the library expands with each additional treatment.

AIM

The goal is to validate the cutout library selection software.

METHOD

- Existing blocks connected to original treatment plans were imported into Python to form the basis of a library. Cutouts whose original digitalized plans could not be found had apertures traced, scanned, and digitized using image processing software.
- When a new cutout is requested, it is compared against every cutout in the library using a comparison algorithm. Radial lines are drawn every 1° from the centre of the cutout and the intersection with the queried cutout is determined. The distance between this intersection and the library cutout along the projected ray from the centre is calculated. The library cutout with the lowest average distance is ranked as the best match.
- In order to verify the functionality of the cutout matching algorithm, 106 electron patient plans were anonymised. Three queried cutouts were randomly chosen for each of the following field sizes; 6x6 cm^2, 10x10 cm^2 and 15x15 cm^2.
- Dose planes were exported for the queried cutouts and remaining library cutouts. Each queried cutout dose plane was compared to the other 106 cutouts using 3% and 3mm gamma criteria (VeriSoft v7, PTW). Each plan was standardized by using 9 MeV, phantom and a d_{max} of 2 cm. All plans were normalized the dose to 90% isodose line of 250 cGy.

RESULTS

The ranking from the image comparison algorithm has a strong match with the gamma analysis results, when there are cutouts available within the library that would fulfill the needs clinically, as seen in Table 1. When the gamma analysis comparison % between the queried shape and the library cutout decreases (<60%), the algorithms ranking based on average distance becomes less accurate, as seen in queried cutout 48.

Figures 1, 2 & 3, display the highest gamma analysis rank plotted by the matching algorithm for three of the field sizes examined. The queried cutout shown in blue and the library cutout shown in orange. These figures highlight the functionality of the algorithm. Cutout number 33 and 46 closely match the queried cutouts dosimetrically and this can be seen geometrically also. In figure 3, (cutout number 1) although not a good match clinically, the the matching algorithm correctly ranks this cutout to the available library.

Figures 4, 5 and 6 verify the results of the matching algorithm dosimetrically. These figures display the corresponding gamma analysis results for each of the highest ranked respectively.

In figures 3 and 6, comparing the results outputted from the image comparison algorithm to the gamma analysis on the same match, it is clear where the cutout would fail clinically. This is highlighted by the red areas, where the queried cutout does not overlap with the library cutout resulting in dose going to an area that is not want.

Queried Cutout ID	Library Cutout match	Gamma Annalys is %	Gamma Rank	Algorithm Rank	Queried Cutout ID	Library Cutout match	Gamma Annalysis %	Gamma Rank	Algorithm Rank	Queried Cutout ID	Library Cutout match	Gamma Annalysis %	Gamma Rank	Algorithm Rank
Field Size 6x6 cm														
11	33	87.4	1	1	33	11	83.9	1	1	28	31	56.6	1	3
	28	52.4	2	2		31	65.2	2	3		57	54	2	2
	92	43.3	3	3		28	60.4	3	2		33	53.6	3	1
Field Size 10x10 cm														
3	52	58.3	1	1	14	46	84.3	1	1	52	38	63.4	1	1
	38	51.1	2	2		15	68.5	2	2		3	59.2	2	2
	24	48.3	3	3		53	63.9	3	3		44	57.5	3	3
Field Size 15x15 cm														
1	4	42.4	1	1	48	102	36.4	1	3	102	4	33.9	1	1
	94	39.4	2	2		1	20.9	2	2		1	34.7	2	2
	102	34.2	3	3		4	14.1	3	1		48	28.5	3	3

Table 1: Gamma analysis for each queried cutout for various field sizes with it's corresponding average distance rank from the comparison algorithm

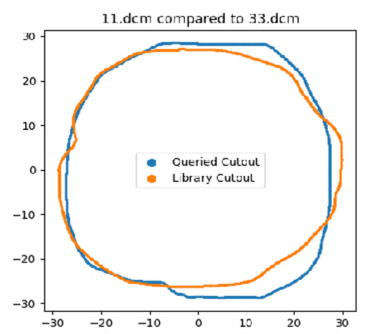

Figure 1: Plot of 11dcm and 33.dcm created by the program

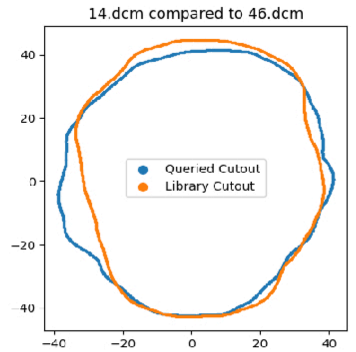

Figure 2: Plot of 14.dcm and 46.dcm created by the program

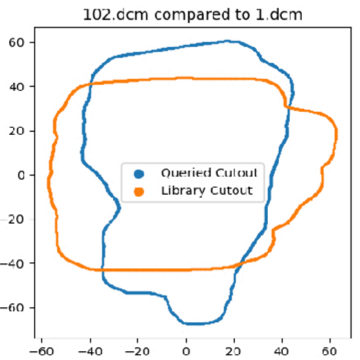

Figure 3: Plot of 102.dcm and 1.dcm created by the program algorithm

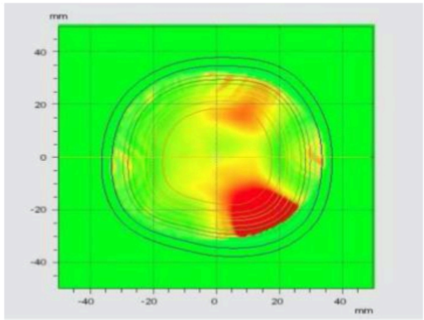

Figure 4: Gamma analysis results for 3.dcm compared to 52.dcm

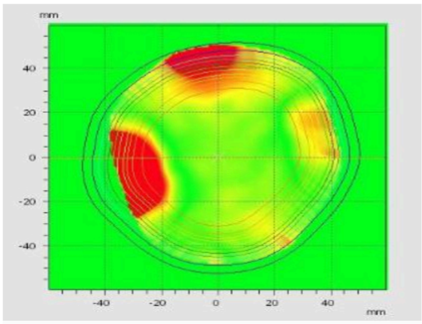

Figure 5: Plot of 11dcm and 33.dcm created by the program

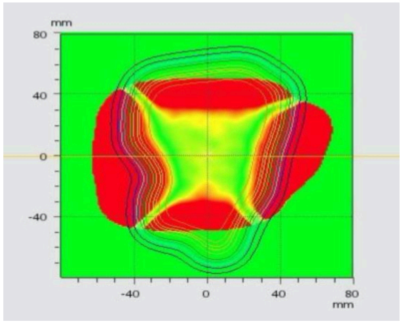

Figure 6: Plot of 102dcm and 1.dcm created by the program

CONCLUSIONS

The matching algorithm works well for cutouts where the average distance between both cutouts is small. However, once this distance increases to an average distance greater than 4 mm, the gamma comparison tends to dramatically decrease to values <60%. Below theses gamma values there seems to be an increasing discrepancy between the image comparison algorithm ranking and the gamma analysis comparison software results. However, this does show that the matching algorithm is functioning correctly as if the gamma is below 60% the cutout is already more than likely unsuitable to be used clinically as this could increase dose to health tissues.

Immediate future work involves testing this software tool in a clinical environment with a dosimetrist. Once a plan has been created, the plan can be anonymised and exported and compared to the library of cutouts. This should be dosimetrically verified using the appropriate gamma analysis criteria by measuring the dose distribution using a phantom. The planners have the ultimate responsibility to design a cutout which provides the best treatment plan, whether that is from the cutout library or from the fabricator if there is no suitable cutout available. If the latter option is chosen that new design will be added to the library, available for future comparisons.

Future work involves integrating the aperture comparison tool into the treatment planning software via API scripting. Once this interface is established the library can actively update, providing better results with time.

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