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Neuartige Eingabekonzepte für inverse, intensitätsmodulierte Planungssysteme in der Strahlentherapie

New concept of input into inverse imrt planning systems

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Purpose

Common imrt systems often need complex input to generate useful radiotherapy treatment plans. This becomes all the more fatal, as it occurs in processes of the daily clinical routine. To avoid this, we present some different input concepts to lower handling complexity for imrt planning systems. Based on this we implement a easy-to-handle inverse imrt planning system.

Materials and Methods

For inverse imrt planning systems four domains of input are important:
- Hardware information (e.g. data of linac, mlc)
- Patient density data (CT data)
- Patient structures
- Structure dose information and parameterizing inverse planning

Hardware information can be considered as not critically, because this data are entered mainly at hardware setup. The process of gathering patient density data is meanwhile good enough for clinical routine. To identify structures in the density data human help is still necessary, but can be assist by computer algorithms.
This work focus on the last domain, the input of structure dose information and the parameterization of the inverse planning process. In fact, we choose a straight forward approach to transfer the most simple-but-useful representative input into a imrt planning system. The refor we develop the following concepts:

Virtualization

In combination with quadratic optimization algorithm, we use an advanced virtual modelling of voxels in our constraint formulation, enabling a definite description for overlapping structures in disjoined constraints and differentiating between organs with serial/parallel architecture.

Priorization

Weighting between structures or defining acceptable dose variances of structures (e.g. tumor vs. oar respectively oar vs. oar) is realized by assigning one simple (symbolic) priority value per structure.

Scaling

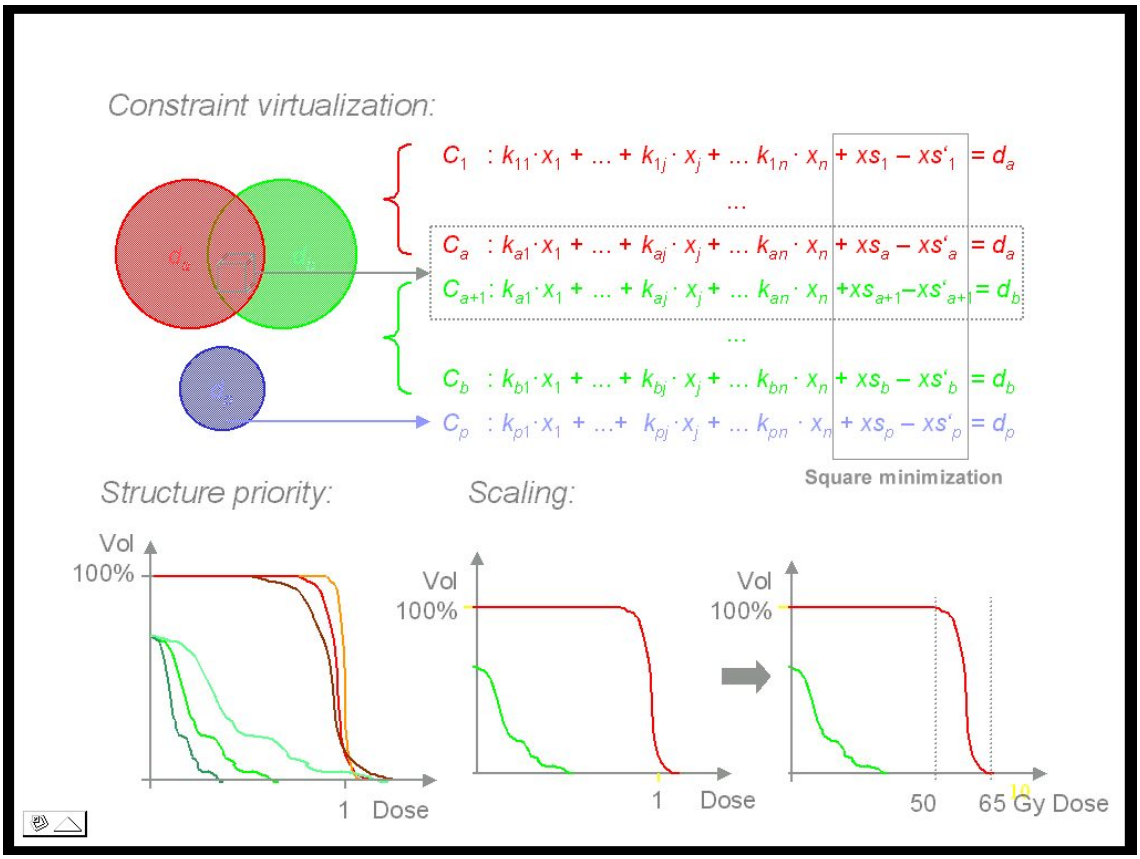
The concept of scaling after the optimization process implicate relative dose values at input time. This offers large benefits: The oncologist only characterizes all segmented structures either as „planning target volume" or „organ at risk", with no certain dose preferences. The following planning algorithm can optimize best and guarantee a solution. The scaling itself is intuitive. Just scale the dose axis in resulting dose volume histogram by mouse to achieve best absolute dose results for the individual requirements of the patient.

Results

Compared to the predecessor system developed in our institute (and to other systems as well) the new concepts minimize user time and user knowledge for system handling significantly along with a slightly increase of computation time. But the most important fact is, that the presented concepts also increase the quality of generated plans.

Conclusion

The presented concepts increase inverse imrt planning systems in usability and quality aspects and also can lower costs.


Constraint virtualization:
$C_1 : k_{11} \cdot x_1 + \ldots + k_{1j} \cdot x_j + \ldots k_{1n} \cdot x_n + xs_1 - xs'_1 = d_a$
...
$C_a : k_{a1} \cdot x_1 + \ldots + k_{aj} \cdot x_j + \ldots k_{an} \cdot x_n + xs_a - xs'_a = d_a$
$C_{a+1} : k_{a1} \cdot x_1 + \ldots + k_{aj} \cdot x_j + \ldots k_{an} \cdot x_n + xs_{a+1} - xs'_{a+1} = d_b$
...
$C_b : k_{b1} \cdot x_1 + \ldots + k_{bj} \cdot x_j + \ldots k_{bn} \cdot x_n + xs_b - xs'_b = d_b$
$C_p : k_{p1} \cdot x_1 + \ldots + k_{pj} \cdot x_j + \ldots k_{pn} \cdot x_n + xs_p - xs'_p = d_p$
Square minimization
Structure priority:
Scaling:
Vol
100%
1
Dose
Vol
100%
1
Dose
Vol
100%
50
65 Gy Dose

Common input vs. New input concept

Structure	d^{min}	d^{max}	Dose-Volumen-Constraints
PTV	40 Gy	80 Gy	(95%, > 70 Gy)
Myelon	0	47 Gy	
Left Lung	0	60 Gy	(30%, opt!) (50%, opt!)
Right Lung	0	55 Gy	(30%, opt!) (50%, opt!)

Structure	Type	Priority	Function
PTV	PTV	100	-
Myelon	OAR	10	(serial)
Left Lung	OAR	1	(parallel)
Right Lung	OAR	1	(parallel)

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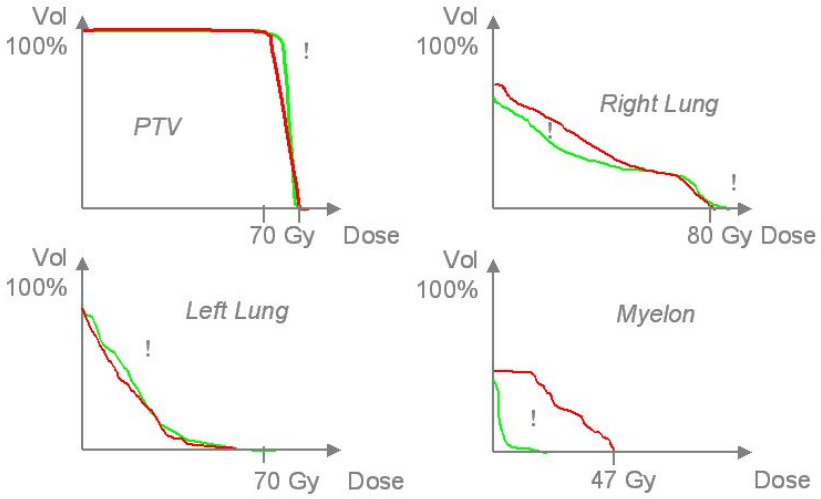
DVH of lung tumor

common input / new input concept



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