

Contents

1	Introduction	1
2	Mathematical preliminaries	5
2.1	The general multicriteria convex constrained optimization problem	5
2.1.1	As single criteria problem	5
2.1.2	As lexicographic problem	5
2.2	From optimization to feasibility problem: The level set scheme	6
2.3	Solving feasibility problems: Projection methods	8
2.4	Perturbing the iteration process	9
2.4.1	Bounded perturbation resilience	9
2.4.2	Superiorization	10
2.5	New results about perturbations	11
2.5.1	The relation of inner and outer perturbations	11
2.5.2	Bounded perturbation resilience of perturbed iteration schemes	15
3	Optimization in IMRT planning	21
3.1	IMRT planning	21
3.2	The optimization problem in IMRT planning	21
3.3	Modeling the IMRT optimization problem	22
3.3.1	Dose calculation	22
3.3.2	Dose evaluation functions	23
3.4	Challenges in IMRT optimization	25
4	Perturbations as superiorization	27
4.1	The superiorized lexicographic optimization scheme	27
4.1.1	Implementation	28
4.2	Results	32
4.2.1	Demonstrating superiorization: A linear optimization problem	32
4.2.2	Applying superiorization in practice: IMRT optimization	33
4.3	Discussion	37
5	Perturbations as anti-zigzag strategy	41
5.1	The perturbed level set scheme	41
5.2	Zigzagging of projection steps in IMRT optimization	43
5.3	Three new variants of perturbations	48
5.3.1	The heavy ball perturbation	48
5.3.2	The Nesterov perturbation	52
5.3.3	The surrogate constraint perturbation	55
5.4	Convergence of the perturbed simultaneous projection method	61
5.4.1	Geometrical analysis	61

5.4.2	Convergence results	64
5.5	Implementation	70
5.6	Results	71
5.6.1	Demonstrating the perturbations: A linear feasibility problem	72
5.6.2	Applying the perturbations in practice: IMRT optimization	75
5.7	Computational effort	92
5.8	Discussion	94
6	Conclusions and perspective	99