

Contents

1	Introduction	1
1.1	The Healthy Brain	4
1.1.1	Selected Regions in the Human Brain	4
1.1.2	Neuronal and Glial Cells in the CNS	7
1.1.3	Open Questions and Challenges	9
1.2	The Pathological Brain	10
1.2.1	Alzheimer's Disease	10
1.2.2	Multiple Sclerosis	12
1.2.3	Open Questions and Challenges	14
1.3	X-ray Interaction with Matter	15
1.3.1	The Complex Index of Refraction	17
1.3.2	Tuning the Interaction	18
1.3.3	Open Questions and Challenges	20
1.4	Phase-sensitive Imaging	21
1.4.1	Hologram Formation	21
1.4.2	A Note on Coherence	22
1.4.3	Wavefront Reconstruction I: Holographic Regime	23
1.4.4	Wavefront Reconstruction II: Edge-enhancement Regime	25
1.4.5	Open Questions and Challenges	27
1.5	Computed Tomography	28
1.5.1	Foundations	28
1.5.2	Tomographic Reconstruction	30
1.5.3	Sampling Criteria	32
1.5.4	Tomographic Artifacts	33
1.5.5	Image Quality Metrics	35
1.5.6	Open Questions and Challenges	36
1.6	Data Analysis by Means of Optimal Transport	37
1.6.1	Foundations	37
1.6.2	Embedding of OT in a Practical Analysis Workflow	39

2	Phase-contrast X-ray Tomography of Neuronal Tissue at Laboratory Sources with Submicron Resolution	63
2.1	Introduction	64
2.2	Methods	66
2.3	Results	70
2.4	Summary and Outlook	79
3	Three-dimensional Virtual Histology of the Cerebral Cortex based on Phase-Contrast X-ray Tomography	89
3.1	Introduction	89
3.2	Results	96
3.3	Discussion	105
3.4	Supplemental Document	109
4	Three-dimensional Virtual Histology of the Human Hippocampus based on Phase-Contrast Computed-Tomography	127
4.1	Introduction	128
4.2	Results I: Multiscale Tomography of the Hippocampus	132
4.3	Results II: Geometric and Statistical Analysis	138
4.4	Discussion	147
4.5	Materials and Methods	150
4.6	SI Appendix	153
5	Towards Correlative Imaging of Neuronal Tissue by Phase-Contrast X-ray Tomography and SEM	187
5.1	Introduction	188
5.2	Methods	190
5.3	Results	193
5.4	Discussion and Outlook	196
6	Conclusion and Outlook	203
A	Appendix	211
A.1	Towards X-ray Fluorescence Tomography	211
A.2	Further Details on Working with the Nanofocus PC-CT Setup TiNa	225
A.3	Measurements and Analysis of the X-ray Spectrum	241
	Author Contributions	255

List of Publications	257
Danksagung	261
Curriculum Vitae	263