Universiteit
Leiden
The Netherlands

Deep learning for tomographic reconstruction with limited data

Hendriksen, A.A.

Citation
Hendriksen, A. A. (2022, March 3). *Deep learning for tomographic reconstruction with limited data*. Retrieved from https://hdl.handle.net/1887/3277969

Version:	Publisher's Version
License:	Licence agreement concerning inclusion of doctoral thesis in the Institutional Repository of the University of Leiden
Downloaded from:	https://hdl.handle.net/1887/3277969

Note: To cite this publication please use the final published version (if applicable).

Bibliography

[1] W. van Aarle, W. J. Palenstijn, J. Cant, E. Janssens, F. Bleichrodt, A. Dabravolski, J. De Beenhouwer, K. Joost Batenburg, and J. Sijbers. "Fast and Flexible X-Ray Tomography Using the ASTRA Toolbox". *Optics Express* 24.22 (2016), p. 25129 (cit. on pp. 92, 96, 152).

[2] W. van Aarle, W. J. Palenstijn, J. De Beenhouwer, T. Altantzis, S. Bals, K. J. Batenburg, and J. Sijbers. "The ASTRA Toolbox: a Platform for Advanced Algorithm Development in Electron Tomography". *Ultramicroscopy* 157 (2015), pp. 35–47 (cit. on pp. 33, 59, 64, 92).

[3] K. Aditya Mohan, S. V. Venkatakrishnan, J. W. Gibbs, E. B. Gulsoy, X. Xiao, M. De Graef, P. W. Voorhees, and C. A. Bouman. "TIMBIR: a Method for Time-Space Reconstruction From Interlaced Views". *IEEE Transactions on Computational Imaging* 1.2 (2015), pp. 96–111 (cit. on pp. 81, 119).

[4] J. Adler and O. Öktem. "Deep Bayesian Inversion". *CoRR* (2018). arXiv: `1811.05910 [stat.ML]` (cit. on pp. 12, 54).

[5] J. Adler and O. Öktem. "Learned Primal-Dual Reconstruction". *IEEE Transactions on Medical Imaging* (2018), pp. 1–1 (cit. on pp. 11, 62, 74).

[6] A. Andersen. "Simultaneous Algebraic Reconstruction Technique (SART): a Superior Implementation of the ART Algorithm". *Ultrasonic Imaging* 6.1 (1984), pp. 81–94 (cit. on p. 10).

[7] M. Arjovsky, S. Chintala, and L. Bottou. "Wasserstein Generative Adversarial Networks". In: *Proceedings of the 34th International Conference on Machine Learning, ICML 2017, Sydney, NSW, Australia, 6-11 August 2017*. Ed. by D. Precup and Y. W. Teh. Vol. 70. Proceedings of Machine Learning Research. PMLR, 2017, pp. 214–223 (cit. on pp. 14, 118).

[8] S. R. Arridge. "Optical Tomography in Medical Imaging". *Inverse Problems* 15.2 (1999), R41–R93 (cit. on p. 21).

[9] S. Arridge, P. Maass, O. Öktem, and C.-B. Schönlieb. "Solving Inverse Problems Using Data-Driven Models". *Acta Numerica* 28 (2019), pp. 1–174 (cit. on p. 12).

[10] G. Artioli, T. Cerulli, G. Cruciani, M. C. Dalconi, G. Ferrari, M. Parisatto, A. Rack, and R. Tucoulou. "X-Ray Diffraction Microtomography (XRD-CT), a Novel Tool for Non-Invasive Mapping of Phase Development in Cement Materials". *Analytical and Bioanalytical Chemistry* 397.6 (2010), pp. 2131–2136 (cit. on pp. 45, 74, 81).

[11] G. Ashiotis, A. Deschildre, Z. Nawaz, J. P. Wright, D. Karkoulis, F. E. Picca, and J. Kieffer. "The Fast Azimuthal Integration Python Library: pyFai". *Journal of Applied Crystallography* 48.2 (2015), pp. 510–519 (cit. on p. 152).

[12] S.-M. Bak, Z. Shadike, R. Lin, X. Yu, and X.-Q. Yang. "In Situ/operando Synchrotron-Based X-Ray Techniques for Lithium-Ion Battery Research". *NPG Asia Materials* 10.7 (2018), pp. 563–580 (cit. on p. 4).

[13] K. J. Batenburg and J. Sijbers. "DART: a Practical Reconstruction Algorithm for Discrete Tomography". *IEEE Transactions on Image Processing* 20.9 (2011), pp. 2542–2553 (cit. on p. 23).

[14] J. Batson and L. Royer. "Noise2Self: Blind Denoising by Self-Supervision". In: *Proceedings of the 36th International Conference on Machine Learning*. Vol. 97. PMLR, 2019, pp. 524–533 (cit. on pp. 46, 48–50, 54, 65, 69–71, 74, 77).

[15] A. Beck and M. Teboulle. "Fast Gradient-Based Algorithms for Constrained Total Variation Image Denoising and Deblurring Problems". *IEEE Transactions on Image Processing* 18.11 (2009), pp. 2419–2434 (cit. on pp. 11, 60).

[16] C. Belthangady and L. A. Royer. "Applications, Promises, and Pitfalls of Deep Learning for Fluorescence Image Reconstruction". *Nature Methods* 16.12 (2019), pp. 1215–1225 (cit. on pp. 45, 46, 74, 76).

[17] T. Bendory, A. Bartesaghi, and A. Singer. "Single-Particle Cryo-Electron Microscopy: Mathematical Theory, Computational Challenges, and Opportunities". *IEEE Signal Processing Magazine* 37.2 (2020), pp. 58–76 (cit. on pp. 2, 102).

[18] T. Bepler, K. Kelley, A. J. Noble, and B. Berger. "Topaz-Denoise: General Deep Denoising Models for Cryo-EM and Cryo-ET". *Nature Communications* 11.1 (Oct. 2020) (cit. on p. 119).

[19] J. Bian, J. H. Siewerdsen, X. Han, E. Y. Sidky, J. L. Prince, C. A. Pelizzari, and X. Pan. "Evaluation of Sparse-View Reconstruction From Flat-Panel-Detector Cone-Beam CT". *Physics in Medicine and Biology* 55.22 (2010), pp. 6575–6599 (cit. on p. 23).

[20] A. Biguri, R. Lindroos, R. Bryll, H. Towsyfyan, H. Deyhle, I. E. k. Harrane, R. Boardman, M. Mavrogordato, M. Dosanjh, S. Hancock, and et al. "Arbitrarily Large Tomography With Iterative Algorithms on Multiple GPUs Using the TIGRE Toolbox". *Journal of Parallel and Distributed Computing* 146 (2020), pp. 52–63 (cit. on p. 92).

[21] F. Bleichrodt, T. van Leeuwen, W. J. Palenstijn, W. van Aarle, J. Sijbers, and K. J. Batenburg. "Easy Implementation of Advanced Tomography Algorithms Using the ASTRA Toolbox With Spot Operators". *Numerical Algorithms* 71.3 (2015), pp. 673–697 (cit. on pp. 93, 95).

[22] P. Bleuet, E. Welcomme, E. Dooryhée, J. Susini, J.-L. Hodeau, and P. Walter. "Probing the Structure of Heterogeneous Diluted Materials By Diffraction Tomography". *Nature Materials* 7 (2008), pp. 468–472 (cit. on pp. 74, 81).

[23] R. Boistel, N. Pollet, J.-Y. Tinevez, P. Cloetens, and M. Schlenker. "Irradiation Damage To Frog Inner Ear During Synchrotron Radiation Tomographic Investigation". *Journal of Electron Spectroscopy and Related Phenomena* 170.1-3 (2009), pp. 37–41 (cit. on p. 74).

[24] F. G. Bossema, M. Domínguez-Delmás, W. J. Palenstijn, A. Kostenko, J. Dorscheid, S. B. Coban, E. Hermens, and K. J. Batenburg. "A Novel Method for Dendrochronology of Large Historical Wooden Objects Using Line Trajectory X-Ray Tomography". *Scientific Reports* 11.1 (2021) (cit. on p. 2).

[25] D. J. Brenner and E. J. Hall. "Computed Tomography - an Increasing Source of Radiation Exposure". *New England Journal of Medicine* 357.22 (2007), pp. 2277–2284 (cit. on p. 6).

[26] J. Brokish and Y. Bresler. "Sampling Requirements for Circular Cone Beam Tomography". *2006 IEEE Nuclear Science Symposium Conference Record* (2006) (cit. on p. 25).

[27] T.-O. Buchholz, M. Jordan, G. Pigino, and F. Jug. "Cryo-Care: Content-Aware Image Restoration for Cryo-Transmission Electron Microscopy Data". *2019 IEEE 16th International Symposium on Biomedical Imaging (ISBI 2019)* (2019) (cit. on pp. 45, 46, 71, 74).

[28] M. Bührer, M. Stampanoni, X. Rochet, F. Büchi, J. Eller, and F. Marone. "High-Numerical-Aperture Macroscope Optics for Time-Resolved Experiments". *Journal of Synchrotron Radiation* 26.4 (2019), pp. 1161–1172 (cit. on pp. 74, 109, 152).

[29] M. Bührer, H. Xu, J. Eller, J. Sijbers, M. Stampanoni, and F. Marone. "Unveiling Water Dynamics in Fuel Cells From Time-Resolved Tomographic Microscopy Data". *Scientific Reports* 10.1 (2020) (cit. on pp. 19, 74, 79, 83).

[30] M. Bührer, H. Xu, A. A. Hendriksen, F. N. Büchi, J. Eller, M. Stampanoni, and F. Marone. "Deep learning based classification of dynamic processes in time-resolved X-ray tomographic microscopy". *Scientific Reports* 11.1 (Dec. 2021) (cit. on p. 140).

[31] T. M. Buzug. *Computed Tomography : from Photon Statistics to Modern Cone-Beam CT*. Springer, 2008 (cit. on pp. 5–9, 22, 26, 45, 51, 57, 58, 77, 78, 91, 92, 153).

[32] E. Cha, J. Jang, J. Lee, E. Lee, and J. C. Ye. "Boosting CNN Beyond Label in Inverse Problems". *CoRR* (2019). arXiv: `1906.07330 [cs.CV]` (cit. on p. 46).

[33] A. Chambolle and T. Pock. "A First-Order Primal-Dual Algorithm for Convex Problems With Applications To Imaging". *Journal of Mathematical Imaging and Vision* 40.1 (2010), pp. 120–145 (cit. on p. 11).

[34] W. Chang, J. M. Lee, K. Lee, J. H. Yoon, M. H. Yu, J. K. Han, and B. I. Choi. "Assessment of a Model-Based, Iterative Reconstruction Algorithm (MBIR) Regarding Image Quality and Dose Reduction in Liver Computed Tomography". *Investigative Radiology* 48.8 (2013), pp. 598–606 (cit. on pp. 45, 57).

[35] C. Chen, W. Bai, R. H. Davies, A. N. Bhuva, C. H. Manisty, J. B. Augusto, J. C. Moon, N. Aung, A. M. Lee, M. M. Sanghvi, and et al. "Improving the Generalizability of Convolutional Neural Network-Based Segmentation on CMR Images". *Frontiers in Cardiovascular Medicine* 7 (2020) (cit. on p. 13).

[36] R. J. Chen, M. Y. Lu, T. Y. Chen, D. F. K. Williamson, and F. Mahmood. "Synthetic Data in Machine Learning for Medicine and Healthcare". *Nature Biomedical Engineering* 5.6 (June 2021), pp. 493–497 (cit. on p. 14).

[37] Z. Cheng, M. Gadelha, S. Maji, and D. Sheldon. "A Bayesian Perspective on the Deep Image Prior". In: *The IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*. 2019 (cit. on pp. 46, 62).

[38] Ö. Çiçek, A. Abdulkadir, S. S. Lienkamp, T. Brox, and O. Ronneberger. "3D U-Net: Learning Dense Volumetric Segmentation From Sparse Annotation". *Lecture Notes in Computer Science* (2016), pp. 424–432 (cit. on pp. 11, 41, 69).

[39] V. Cnudde and M. N. Boone. "High-Resolution X-ray Computed Tomography in Geosciences: a Review of the Current Technology and Applications". *Earth-Science Reviews* 123 (2013), pp. 1–17 (cit. on pp. 21, 22).

[40] S. B. Coban, A. A. Hendriksen, D. M. Pelt, W. J. Palenstijn, and K. J. Batenburg. *Oatmeal Data: Experimental cone-beam tomographic data for techniques to improve image resolution*. 2018 (cit. on p. 39).

[41] S. B. Coban. "Practical approaches to reconstruction and analysis for 3D and dynamic 3D computed tomography". PhD thesis. The University of Manchester (United Kingdom), 2016 (cit. on p. 5).

[42] S. B. Coban, F. Lucka, W. J. Palenstijn, D. Van Loo, and K. J. Batenburg. "Explorative Imaging and Its Implementation At the Flex-Ray Laboratory". *Journal of Imaging* 6.4 (2020), p. 18 (cit. on pp. 2, 38, 109).

[43] K. Dabov, A. Foi, V. Katkovnik, and K. Egiazarian. "Image Denoising By Sparse 3-D Transform-Domain Collaborative Filtering". *IEEE Transactions on Image Processing* 16.8 (2007), pp. 2080–2095 (cit. on pp. 47, 60).

[44] F. De Carlo, D. Gürsoy, D. J. Ching, K. J. Batenburg, W. Ludwig, L. Mancini, F. Marone, R. Mokso, D. M. Pelt, J. Sijbers, and et al. "TomoBank: a Tomographic Data Repository for Computational X-Ray Science". *Measurement Science and Technology* 29.3 (2018), p. 034004 (cit. on pp. 64, 109, 152).

[45] F. Dennerlein and A. Maier. "Approximate Truncation Robust Computed Tomography-ATRACT". *Physics in Medicine and Biology* 58.17 (2013), pp. 6133–6148 (cit. on p. 30).

[46] S. Dittmer, T. Kluth, P. Maass, and D. Otero Baguer. "Regularization By Architecture: a Deep Prior Approach for Inverse Problems". *Journal of Mathematical Imaging and Vision* 62.3 (2019), pp. 456–470 (cit. on p. 46).

[47] M. L. Eaton. "Chapter 2, Random Vectors". In: *Multivariate Statistics*. Vol. Volume 53. Lecture Notes–Monograph Series. Institute of Mathematical Statistics, 2007, pp. 70–102 (cit. on p. 54).

[48] M. Ebner, F. Geldmacher, F. Marone, M. Stampanoni, and V. Wood. "X-Ray Tomography of Porous, Transition Metal Oxide Based Lithium Ion Battery Electrodes". *Advanced Energy Materials* 3.7 (2013), pp. 845–850 (cit. on p. 4).

[49] M. van Eijnatten, L. Rundo, K. J. Batenburg, F. Lucka, E. Beddowes, C. Caldas, F. A. Gallagher, E. Sala, C.-B. Schönlieb, and R. Woitek. "3D Deformable Registration of Longitudinal Abdominopelvic CT Images Using Unsupervised Deep Learning". *Computer Methods and Programs in Biomedicine* 208 (2021), p. 106261 (cit. on p. 13).

[50] J. Eller, J. Roth, F. Marone, M. Stampanoni, A. Wokaun, and F. N. Büchi. "Implications of Polymer Electrolyte Fuel Cell Exposure To Synchrotron Radiation on Gas Diffusion Layer Water Distribution". *Journal of Power Sources* 245 (2014), pp. 796–800 (cit. on p. 74).

[51] A. Esteva, B. Kuprel, R. A. Novoa, J. Ko, S. M. Swetter, H. M. Blau, and S. Thrun. "Dermatologist-Level Classification of Skin Cancer With Deep Neural Networks". *Nature* 542.7639 (Jan. 2017), pp. 115–118 (cit. on p. 119).

[52] D. Evangelista, M. Terreran, A. Pretto, M. Moro, C. Ferrari, and E. Menegatti. "3D Mapping of X-Ray Images in Inspections of Aerospace Parts". In: *2020 25th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA)*. Vol. 1. 2020, pp. 1223–1226 (cit. on pp. 2, 91).

[53] L. A. Feldkamp, L. C. Davis, and J. W. Kress. "Practical Cone-Beam Algorithm". *Journal of the Optical Society of America A* 1.6 (1984), p. 612 (cit. on pp. 9, 25, 109).

[54] J. A. Fessler. "On NUFFT-Based Gridding for Non-Cartesian MRI". *Journal of Magnetic Resonance* 188.2 (2007), pp. 191–195 (cit. on p. 10).

[55] A. Foi, M. Trimeche, V. Katkovnik, and K. Egiazarian. "Practical Poissonian-Gaussian Noise Modeling and Fitting for Single-Image Raw-Data". *IEEE Transactions on Image Processing* 17.10 (2008), pp. 1737–1754 (cit. on p. 9).

[56] F. García-Moreno, P. H. Kamm, T. R. Neu, F. Bülk, R. Mokso, C. M. Schlepütz, M. Stampanoni, and J. Banhart. "Using X-ray Tomoscopy To Explore the Dynamics of Foaming Metal". *Nature Communications* 10.1 (2019) (cit. on pp. 4, 73, 74, 79).

[57] P. Gilbert. "Iterative Methods for the Three-Dimensional Reconstruction of an Object From Projections". *Journal of theoretical biology* 36.1 (1972), pp. 105–117 (cit. on p. 10).

[58] I. Goodfellow, J. Pouget-Abadie, M. Mirza, B. Xu, D. Warde-Farley, S. Ozair, A. Courville, and Y. Bengio. "Generative Adversarial Nets". In: *Advances in Neural Information Processing Systems 27*. Ed. by Z. Ghahramani, M. Welling, C. Cortes, N. D. Lawrence, and K. Q. Weinberger. Curran Associates, Inc., 2014, pp. 2672–2680 (cit. on p. 118).

[59] R. Gordon, R. Bender, and G. T. Herman. "Algebraic Reconstruction Techniques (ART) for Three-Dimensional Electron Microscopy and X-Ray Photography". *Journal of Theoretical Biology* 29.3 (1970), pp. 471–481 (cit. on p. 10).

[60] J. Gregor and T. Benson. "Computational Analysis and Improvement of SIRT". *IEEE Transactions on Medical Imaging* 27.7 (2008), pp. 918–924 (cit. on pp. 10, 60, 78, 92).

[61] H. Guan and R. Gordon. "Computed Tomography Using Algebraic Reconstruction Techniques (ARTs) With Different Projection Access Schemes: a Comparison Study Under Practical Situations". *Physics in Medicine and Biology* 41.9 (1996), pp. 1727–1743 (cit. on p. 22).

[62] I. Gulrajani, F. Ahmed, M. Arjovsky, V. Dumoulin, and A. C. Courville. "Improved Training of Wasserstein GANs". In: *Advances in Neural Information Processing Systems 30: Annual Conference on Neural Information Processing Systems 2017, December 4-9, 2017, Long Beach, CA, USA*. Ed. by I. Guyon, U. von Luxburg, S. Bengio, H. M. Wallach, R. Fergus, S. V. N. Vishwanathan, and R. Garnett. 2017, pp. 5767–5777 (cit. on p. 14).

[63] V. Gulshan, L. Peng, M. Coram, M. C. Stumpe, D. Wu, A. Narayanaswamy, S. Venugopalan, K. Widner, T. Madams, J. Cuadros, and et al. "Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs". *JAMA* 316.22 (Dec. 2016), p. 2402 (cit. on p. 119).

[64] D. Gürsoy, F. De Carlo, X. Xiao, and C. Jacobsen. "Tomopy: a Framework for the Analysis of Synchrotron Tomographic Data". *Journal of Synchrotron Radiation* 21.5 (2014), pp. 1188–1193 (cit. on pp. 64, 92, 113, 153, 154).

[65] C. R. Harris, K. J. Millman, S. J. van der Walt, R. Gommers, P. Virtanen, D. Cournapeau, E. Wieser, J. Taylor, S. Berg, N. J. Smith, and et al. "Array Programming With NumPy". *Nature* 585.7825 (2020), pp. 357–362 (cit. on pp. 100, 101).

[66] T. Hastie, R. Tibshirani, and J. Friedman. "The Elements of Statistical Learning". *Springer Series in Statistics* (2009) (cit. on pp. 8, 11, 12, 48, 76).

[67] A. Hendriksen. *ahendriksen/cone_balls: v0.2.2*. Version v0.2.2. 2019 (cit. on p. 36).

[68] A. Hendriksen. *ahendriksen/on_the_fly: Paper release*. Version paper-release. 2019 (cit. on p. 41).

[69] A. Hendriksen, R. de Heide, and P. Grünwald. "Optional Stopping With Bayes Factors: a Categorization and Extension of Folklore Results, With an Application To Invariant Situations". *Bayesian Analysis* (2020) (cit. on p. 139).

[70] A. Hendriksen and D. Schut. *ahendriksen/ts_algorithms*. 2021 (cit. on p. 113).

[71] A. A. Hendriksen. *ahendriksenh/msd_pytorch: v0.7.2*. Version v0.7.2. 2019 (cit. on pp. 59, 152).

[72] A. A. Hendriksen, M. Bührer, L. Leone, M. Merlini, N. Vigano, D. M. Pelt, F. Marone, M. di Michiel, and K. J. Batenburg. "Deep Denoising for Multi-Dimensional Synchrotron X-Ray Tomography Without High-Quality Reference Data". *Scientific Reports* 11.1 (2021) (cit. on pp. 73, 139).

[73] A. A. Hendriksen, D. M. Pelt, W. J. Palenstijn, S. B. Coban, and K. J. Batenburg. "On-The-Fly Machine Learning for Improving Image Resolution in Tomography". *Applied Sciences* 9.12 (2019) (cit. on pp. 21, 69, 139).

[74] A. A. Hendriksen, D. Schut, W. J. Palenstijn, N. Viganó, D. M. Kim Jisoo Pelt, T. van Leeuwen, and K. J. Batenburg. "Tomosipo: Fast, Flexible, and Convenient 3D Tomography for Complex Scanning Geometries in Python". *Optics Express* (2021) (cit. on pp. 91, 106, 108, 139).

[75] A. A. Hendriksen, D. M. Pelt, and K. J. Batenburg. "Noise2inverse: Self-Supervised Deep Convolutional Denoising for Tomography". *IEEE Transactions on Computational Imaging* (2020), pp. 1–1 (cit. on pp. 45, 74, 76–79, 87–89, 139).

[76] M. R. Hestenes and E. Stiefel. "Methods of Conjugate Gradients for Solving Linear Systems". *Journal of Research of the National Bureau of Standards* 49.6 (1952) (cit. on p. 10).

[77] M. Holler, M. Odstrcil, M. Guizar-Sicairos, M. Lebugle, E. Müller, S. Finizio, G. Tinti, C. David, J. Zusman, W. Unglaub, and et al. "Three-Dimensional Imaging of Integrated Circuits With Macro- To Nanoscale Zoom". *Nature Electronics* 2.10 (2019), pp. 464–470 (cit. on pp. 73, 74).

[78] P. Isola, J.-Y. Zhu, T. Zhou, and A. A. Efros. "Image-to-image translation with conditional adversarial networks". In: *The IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*. 2017 (cit. on p. 44).

[79] K. Jarrett, K. Kavukcuoglu, M. A. Ranzato, and Y. LeCun. "What Is the Best Multi-Stage Architecture for Object Recognition?" *2009 IEEE 12th International Conference on Computer Vision* (2009) (cit. on pp. 11, 75).

[80] K. H. Jin, H. Gupta, J. Yerly, M. Stuber, and M. Unser. "Time-Dependent Deep Image Prior for Dynamic MRI". *CoRR* (2019). arXiv: `1910.01684 [eess.IV]` (cit. on p. 46).

[81] K. H. Jin, M. T. McCann, E. Froustey, and M. Unser. "Deep Convolutional Neural Network for Inverse Problems in Imaging". *IEEE Transactions on Image Processing* 26.9 (2017), pp. 4509–4522 (cit. on pp. 11, 32).

[82] J. S. Jørgensen, E. Ametova, G. Burca, G. Fardell, E. Papoutsellis, E. Pasca, K. Thielemans, M. Turner, R. Warr, W. R. B. Lionheart, and et al. "Core Imaging Library - Part I: a versatile Python framework for tomographic imaging". *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 379.2204 (July 2021), p. 20200192 (cit. on p. 113).

[83] M. Kalke and S. Siltanen. "Sinogram Interpolation Method for Sparse-Angle Tomography". *Applied Mathematics* 05.03 (2014), pp. 423–441 (cit. on p. 81).

[84] E. Kang, H. J. Koo, D. H. Yang, J. B. Seo, and J. C. Ye. "Cycle-Consistent Adversarial Denoising Network for Multiphase Coronary CT Angiography". *Medical Physics* 46.2 (2018), pp. 550–562 (cit. on pp. 13, 118).

[85] E. Kang, J. Min, and J. C. Ye. "A Deep Convolutional Neural Network Using Directional Wavelets for Low-Dose X-Ray CT Reconstruction". *Medical Physics* 44.10 (2017), e360–e375 (cit. on pp. 2, 11, 45, 46, 51, 74).

[86] N. Kardjilov, I. Manke, A. Hilger, M. Strobl, and J. Banhart. "Neutron Imaging in Materials Science". *Materials Today* 14.6 (2011), pp. 248–256 (cit. on p. 21).

[87] A. G. Kashkooli, S. Farhad, D. U. Lee, K. Feng, S. Litster, S. K. Babu, L. Zhu, and Z. Chen. "Multiscale Modeling of Lithium-Ion Battery Electrodes Based on Nano-Scale X-Ray Computed Tomography". *Journal of Power Sources* 307 (2016), pp. 496–509 (cit. on pp. 23, 74).

[88] A. Katsevich. "An Improved Exact Filtered Backprojection Algorithm for Spiral Computed Tomography". *Advances in Applied Mathematics* 32.4 (2004), pp. 681–697 (cit. on p. 103).

[89] A. Katsevich. "Theoretically Exact Filtered Backprojection-Type Inversion Algorithm for Spiral CT". *SIAM Journal on Applied Mathematics* 62.6 (2002), pp. 2012–2026 (cit. on pp. 9, 92).

[90] B. Kawar, G. Vaksman, and M. Elad. "Snips: Solving Noisy Inverse Problems Stochastically". *CoRR* (2021). arXiv: `2105.14951 [eess.IV]` (cit. on p. 119).

[91] B. Kawar, G. Vaksman, and M. Elad. "Stochastic Image Denoising By Sampling From the Posterior Distribution". *CoRR* (2021). arXiv: `2101.09552 [eess.IV]` (cit. on p. 119).

[92] R. A. Ketcham and W. D. Carlson. "Acquisition, Optimization and Interpretation of X-ray Computed Tomographic Imagery: Applications To the Geosciences". *Computers & Geosciences* 27.4 (2001), pp. 381–400 (cit. on pp. 4, 22, 23).

[93] J. Kim, M. Kagias, F. Marone, and M. Stampanoni. "X-Ray Scattering Tensor Tomography With Circular Gratings". *Applied Physics Letters* 116.13 (2020), p. 134102 (cit. on pp. 20, 91, 107–109).

[94] D. P. Kingma and J. Ba. "Adam: A Method for Stochastic Optimization". In: *3rd International Conference on Learning Representations, ICLR 2015, San Diego, CA, USA, May 7-9, 2015, Conference Track Proceedings*. Ed. by Y. Bengio and Y. LeCun. 2015 (cit. on pp. 34, 60).

[95] A. M. Kingston, G. R. Myers, S. J. Latham, B. Recur, H. Li, and A. P. Sheppard. "Space-Filling X-ray Source Trajectories for Efficient Scanning in Large-Angle Cone-Beam Computed Tomography". *IEEE Transactions on Computational Imaging* 4.3 (2018), pp. 447–458 (cit. on pp. 5, 25).

[96] F. Knoll, J. Zbontar, A. Sriram, M. J. Muckley, M. Bruno, A. Defazio, M. Parente, K. J. Geras, J. Katsnelson, H. Chandarana, and et al. "fastMRI: a Publicly Available Raw K-Space and DICOM Dataset of Knee Images for Accelerated MR Image Reconstruction Using Machine Learning". *Radiology: Artificial Intelligence* 2.1 (2020) (cit. on pp. 13, 71).

[97] H. Kobayashi, A. C. Solak, J. Batson, and L. A. Royer. "Image Deconvolution Via Noise-Tolerant Self-Supervised Inversion". *CoRR* (2020). arXiv: `2006.06156 [cs.CV]` (cit. on p. 74).

[98] F. K. Kopp, R. A. Nasirudin, K. Mei, A. Fehringer, F. Pfeiffer, E. J. Rummeny, and P. B. Noël. "Region of Interest Processing for Iterative Reconstruction in X-ray Computed Tomography". *Medical Imaging 2015: Physics of Medical Imaging* (2015) (cit. on p. 26).

[99] A. Kostenko, W. Palenstijn, S. Coban, A. Hendriksen, R. van Liere, and K. Batenburg. "Prototyping X-Ray Tomographic Reconstruction Pipelines With Flexbox". *SoftwareX* 11 (2020), p. 100364 (cit. on p. 139).

[100] A. Krull, T.-O. Buchholz, and F. Jug. "Noise2Void - Learning Denoising From Single Noisy Images". In: *The IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*. 2019 (cit. on pp. 46, 47, 74).

[101] M. Krumm, C. Sauerwein, V. Hämmerle, S. Heile, T. Schön, A. Jung, and M. Sindel. "Rapid robotic X-ray computed tomography of large assemblies in automotive production". In: *Proceedings of the 8th Conference on Industrial Computed Tomography (iCT 2018), Wels, Austria*. 2018, pp. 6–9 (cit. on p. 91).

[102] P. Kuchment and L. Kunyansky. "Mathematics of Photoacoustic and Thermoacoustic Tomography". In: *Handbook of Mathematical Methods in Imaging*. Ed. by O. Scherzer. New York, NY: Springer New York, 2011, pp. 817–865 (cit. on p. 45).

[103] M. J. Lagerwerf, A. A. Hendriksen, J.-W. Buurlage, and K. J. Batenburg. "Noise2Filter: Fast, Self-Supervised Learning and Real-Time Reconstruction for 3D Computed Tomography". *Machine Learning: Science and Technology* 2.1 (2020), p. 015012 (cit. on pp. 119, 139).

[104] S. Laine, T. Karras, J. Lehtinen, and T. Aila. "High-Quality Self-Supervised Deep Image Denoising". In: *Advances in Neural Information Processing Systems 32*. Curran Associates, Inc., 2019, pp. 6970–6980 (cit. on p. 46).

[105] L. Landweber. "An Iteration Formula for Fredholm Integral Equations of the First Kind". *American Journal of Mathematics* 73.3 (1951), p. 615 (cit. on pp. 10, 95).

[106] C. Ledig, L. Theis, F. Huszar, J. Caballero, A. Cunningham, A. Acosta, A. Aitken, A. Tejani, J. Totz, Z. Wang, and W. Shi. "Photo-realistic single image super-resolution using a generative adversarial network". In: *The IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*. 2017 (cit. on pp. 23, 26, 44, 118).

[107] J. Lehtinen, J. Munkberg, J. Hasselgren, S. Laine, T. Karras, M. Aittala, and T. Aila. "Noise2Noise: Learning Image Restoration without Clean Data". In: *Proceedings of the 35th International Conference on Machine Learning*. PMLR, 2018, pp. 2965–2974 (cit. on pp. 46, 48, 50, 72, 74).

[108] M. Li, H. Yang, and H. Kudo. "An Accurate Iterative Reconstruction Algorithm for Sparse Objects: Application To 3D Blood Vessel Reconstruction From a Limited Number of Projections". *Physics in Medicine and Biology* 47.15 (2002), pp. 2599–2609 (cit. on p. 23).

[109] M. Liebi, M. Georgiadis, J. Kohlbrecher, M. Holler, J. Raabe, I. Usov, A. Menzel, P. Schneider, O. Bunk, and M. Guizar-Sicairos. "Small-Angle X-Ray Scattering Tensor Tomography: Model of the Three-Dimensional Reciprocal-Space Map, Reconstruction Algorithm and Angular Sampling requirements". *Acta Crystallographica Section A* 74.1 (2018), pp. 12–24 (cit. on p. 108).

[110] M. Liebi, M. Georgiadis, A. Menzel, P. Schneider, J. Kohlbrecher, O. Bunk, and M. Guizar-Sicairos. "Nanostructure Surveys of Macroscopic Specimens By Small-Angle Scattering Tensor Tomography". *Nature* 527.7578 (2015), pp. 349–352 (cit. on p. 107).

[111] H. Liu, S. Kazemiabnavi, A. Grenier, G. Vaughan, M. Di Michiel, B. J. Polzin, K. Thornton, K. W. Chapman, and P. J. Chupas. "Quantifying Reaction and Rate Heterogeneity in Battery Electrodes in 3D Through Operando X-Ray Diffraction Computed Tomography". *ACS Applied Materials & Interfaces* 11.20 (2019), pp. 18386–18394 (cit. on p. 4).

[112] J. Liu, Y. Sun, C. Eldeniz, W. Gan, H. An, and U. S. Kamilov. "RARE: Image Reconstruction Using Deep Priors Learned Without Ground Truth". *IEEE Journal of Selected Topics in Signal Processing* (2020), pp. 1–1 (cit. on pp. 46, 74, 81).

[113] G. Lovric, S. F. Barré, J. C. Schittny, M. Roth-Kleiner, M. Stampanoni, and R. Mokso. "Dose Optimization Approach To Fast X-Ray Microtomography of the Lung Alveoli". *Journal of Applied Crystallography* 46.4 (2013), pp. 856–860 (cit. on p. 74).

[114] C. Maaß, M. Knaup, and M. Kachelrieß. "New Approaches To Region of Interest Computed Tomography". *Medical Physics* 38.6Part1 (2011), pp. 2868–2878 (cit. on p. 30).

[115] E. Maire and P. J. Withers. "Quantitative X-Ray Tomography". *International Materials Reviews* 59.1 (2013), pp. 1–43 (cit. on pp. 4, 119).

[116] Y. Makinen, L. Azzari, and A. Foi. "Exact Transform-Domain Noise Variance for Collaborative Filtering of Stationary Correlated Noise". *2019 IEEE International Conference on Image Processing (ICIP)* (2019) (cit. on p. 60).

[117] A. Malecki, G. Potdevin, T. Biernath, E. Eggl, K. Willer, T. Lasser, J. Maisenbacher, J. Gibmeier, A. Wanner, and F. Pfeiffer. "X-Ray Tensor Tomography". *EPL (Europhysics Letters)* 105.3 (2014), p. 38002 (cit. on pp. 107, 108).

[118] F. Marone and M. Stampanoni. "Regridding Reconstruction Algorithm for Real-Time Tomographic Imaging". *Journal of Synchrotron Radiation* 19.6 (2012), pp. 1029–1037 (cit. on pp. 10, 19, 45, 78, 83, 153).

[119] D. N. Mastronarde and S. R. Held. "Automated Tilt Series Alignment and Tomographic Reconstruction in IMOD". *Journal of Structural Biology* 197.2 (2017), pp. 102–113 (cit. on p. 92).

[120] G. Mataev, P. Milanfar, and M. Elad. "DeepRED: Deep Image Prior Powered by RED". In: *The IEEE International Conference on Computer Vision (ICCV) Workshops*. 2019 (cit. on p. 46).

[121] G. Matrone, A. S. Savoia, G. Caliano, and G. Magenes. "The Delay Multiply and Sum Beamforming Algorithm in Ultrasound B-Mode Medical Imaging". *IEEE Transactions on Medical Imaging* 34.4 (2015), pp. 940–949 (cit. on pp. 45, 71).

[122] M. T. McCann, K. H. Jin, and M. Unser. "Convolutional Neural Networks for Inverse Problems in Imaging: a Review". *IEEE Signal Processing Magazine* 34.6 (2017), pp. 85–95 (cit. on pp. 11, 75).

[123] C. H. McCollough, A. C. Bartley, R. E. Carter, B. Chen, T. A. Drees, P. Edwards, D. R. Holmes, A. E. Huang, F. Khan, S. Leng, and et al. "Low-Dose CT for the Detection and Classification of Metastatic Liver Lesions: Results of the 2016 Low Dose CT Grand Challenge". *Medical Physics* 44.10 (2017), e339–e352 (cit. on pp. 4, 13, 45, 62, 71).

[124] S. A. McDonald, P. Reischig, C. Holzner, E. M. Lauridsen, P. J. Withers, A. P. Merkle, and M. Feser. "Non-Destructive Mapping of Grain Orientations in 3D By Laboratory X-Ray Microscopy". *Scientific Reports* 5.1 (2015) (cit. on p. 104).

[125] L. Metz, B. Poole, D. Pfau, and J. Sohl-Dickstein. "Unrolled Generative Adversarial Networks". In: *5th International Conference on Learning Representations, ICLR 2017, Toulon, France, April 24-26, 2017, Conference Track Proceedings*. 2017 (cit. on p. 14).

[126] C. A. Metzler, A. Mousavi, R. Heckel, and R. G. Baraniuk. "Unsupervised Learning With Stein's Unbiased Risk Estimator". *CoRR* (2018). arXiv: `1805.10531 [stat.ML]` (cit. on p. 46).

[127] P. Midgley and M. Weyland. "3D Electron Microscopy in the Physical Sciences: the Development of Z-Contrast and EFTEM Tomography". *Ultramicroscopy* 96.3-4 (2003), pp. 413–431 (cit. on p. 58).

[128] P. A. Midgley and R. E. Dunin-Borkowski. "Electron Tomography and Holography in Materials Science". *Nature Materials* 8.4 (2009), pp. 271–280 (cit. on pp. 21, 98).

[129] J. Minnema, M. Van Eijnatten, J. Wolff, A. A. Hendriksen, K. J. Batenburg, and T. Forouzanfar. "CT Image Segmentation for Additive Manufactured Skull Implants Using Deep Learning". en. *Transactions on Additive Manufacturing Meets Medicine* (2019), Vol 1 (2019): Trans. AMMM (cit. on p. 139).

[130] A. Mirone, E. Brun, E. Gouillart, P. Tafforeau, and J. Kieffer. "The PyHST2 Hybrid Distributed Code for High Speed Tomographic Reconstruction With Iterative Reconstruction and a Priori Knowledge Capabilities". *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms* 324 (2014), pp. 41–48 (cit. on p. 92).

[131] R. Mokso, C. M. Schlepütz, G. Theidel, H. Billich, E. Schmid, T. Celcer, G. Mikuljan, L. Sala, F. Marone, N. Schlumpf, and et al. "GigaFRoST: the Gigabit Fast Readout System for Tomography". *Journal of Synchrotron Radiation* 24.6 (2017), pp. 1250–1259 (cit. on pp. 6, 118).

[132] K. Mueller. "Fast and accurate three-dimensional reconstruction from cone-beam projection data using algebraic methods". PhD thesis. The Ohio State University, 1998 (cit. on p. 22).

[133] V. Nair and G. E. Hinton. "Rectified Linear Units Improve Restricted Boltzmann Machines". In: *Proceedings of the 27th International Conference on Machine Learning*. PMLR, 2010, pp. 807–814 (cit. on pp. 11, 75).

[134] F. Natterer. *The mathematics of computerized tomography*. SIAM, 2001 (cit. on pp. 9, 10).

[135] K. Niinimäki, S. Siltanen, and V. Kolehmainen. "Bayesian Multiresolution Method for Local Tomography in Dental X-ray Imaging". *Physics in Medicine and Biology* 52.22 (2007), pp. 6663–6678 (cit. on p. 22).

[136] R. Okuta, Y. Unno, D. Nishino, S. Hido, and C. Loomis. "CuPy: A NumPy-Compatible Library for NVIDIA GPU Calculations". In: *Proceedings of Workshop on Machine Learning Systems (LearningSys) in The Thirty-first Annual Conference on Neural Information Processing Systems (NIPS)*. 2017 (cit. on p. 100).

[137] D. Paganin, S. C. Mayo, T. E. Gureyev, P. R. Miller, and S. W. Wilkins. "Simultaneous Phase and Amplitude Extraction From a Single Defocused Image of a Homogeneous Object". *Journal of Microscopy* 206.1 (2002), pp. 33–40 (cit. on p. 83).

[138] X. Pan, E. Y. Sidky, and M. Vannier. "Why Do Commercial CT Scanners Still Employ Traditional, Filtered Back-Projection for Image Reconstruction?" *Inverse Problems* 25.12 (2009), p. 123009 (cit. on p. 92).

[139] A. Paszke, S. Gross, S. Chintala, G. Chanan, E. Yang, Z. DeVito, Z. Lin, A. Desmaison, L. Antiga, and A. Lerer. "Automatic differentiation in PyTorch". In: *NIPS-W*. 2017 (cit. on pp. 34, 68, 93, 100).

[140] D. M. Pelt, K. J. Batenburg, and J. A. Sethian. "Improving Tomographic Reconstruction From Limited Data Using Mixed-Scale Dense Convolutional Neural Networks". *Journal of Imaging* 4.11 (2018), p. 128 (cit. on pp. 9, 11, 13, 32, 45, 59, 69, 74).

[141] D. M. Pelt, D. Gürsoy, W. J. Palenstijn, J. Sijbers, F. De Carlo, and K. J. Batenburg. "Integration of TomoPy and the ASTRA Toolbox for Advanced Processing and Reconstruction of Tomographic Synchrotron Data". *Journal of Synchrotron Radiation* 23.3 (2016), pp. 842–849 (cit. on p. 10).

[142] D. M. Pelt, A. A. Hendriksen, and K. J. Batenburg. "Foam-Like Phantoms for Comparing Tomography Algorithms". *Journal of Synchrotron Radiation* 29.1 (Jan. 2022) (cit. on p. 140).

[143] D. M. Pelt and J. A. Sethian. "A Mixed-Scale Dense Convolutional Neural Network for Image Analysis". *Proceedings of the National Academy of Sciences* 115.2 (2017), pp. 254–259 (cit. on pp. 11, 32, 34, 59, 68, 69, 82, 152).

[144] D. M. Pelt and K. J. Batenburg. "Fast Tomographic Reconstruction From Limited Data Using Artificial Neural Networks". *IEEE Transactions on Image Processing* 22.12 (2013), pp. 5238–5251 (cit. on p. 119).

[145] J. M. Perkel. "Why Jupyter Is Data Scientists' Computational Notebook of Choice". *Nature* 563.7732 (2018), pp. 145–147 (cit. on p. 93).

[146] P. Pietsch and V. Wood. "X-Ray Tomography for Lithium Ion Battery Research: a Practical Guide". *Annual Review of Materials Research* 47.1 (2017), pp. 451–479 (cit. on p. 73).

[147] G. E. Possin and C.-Y. Wei. *CT array with improved photosensor linearity and reduced crosstalk*. US Patent 5,430,298. 1995 (cit. on p. 25).

[148] J. Poudel, Y. Lou, and M. A. Anastasio. "A Survey of Computational Frameworks for Solving the Acoustic Inverse Problem in Three-Dimensional Photoacoustic Computed Tomography". *Physics in Medicine & Biology* 64.14 (2019), 14TR01 (cit. on p. 45).

[149] Y. Quan, M. Chen, T. Pang, and H. Ji. "Self2self With Dropout: Learning Self-Supervised Denoising From Single Image". *2020 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR)* (2020) (cit. on p. 74).

[150] M. Ravasi and I. Vasconcelos. "Pylops — a Linear-Operator Python Library for Scalable Algebra and Optimization". *SoftwareX* 11 (2020), p. 100361 (cit. on pp. 92, 113).

[151] S. V. Ravuri and O. Vinyals. "Classification Accuracy Score for Conditional Generative Models". In: *Advances in Neural Information Processing Systems 32: Annual Conference on Neural Information Processing Systems 2019, NeurIPS 2019, December 8-14, 2019, Vancouver, BC, Canada*. Ed. by H. M. Wallach, H. Larochelle, A. Beygelzimer, F. d'Alché-Buc, E. B. Fox, and R. Garnett. 2019, pp. 12247–12258 (cit. on p. 14).

[152] S. D. Rawson, J. Maksimcuka, P. J. Withers, and S. H. Cartmell. "X-ray Computed Tomography in Life Sciences". *BMC Biology* 18.21 (2020) (cit. on p. 73).

[153] S. J. Reddi, S. Kale, and S. Kumar. "On the Convergence of ADAM and Beyond". In: *International Conference on Learning Representations*. 2018 (cit. on pp. 11, 76, 152).

[154] D. Rogers, D. Rogers, J. Adams, and M.-H. (1968-1995). *Mathematical Elements for Computer Graphics*. McGraw-Hill, 1990 (cit. on p. 98).

[155] Y. Romano, J. Isidoro, and P. Milanfar. "RAISR: Rapid and Accurate Image Super Resolution". *IEEE Transactions on Computational Imaging* 3.1 (2017), pp. 110–125 (cit. on p. 23).

[156] O. Ronneberger, P. Fischer, and T. Brox. "U-Net: Convolutional Networks for Biomedical Image Segmentation". *Medical Image Computing and Computer-Assisted Intervention - MICCAI 2015* (2015), pp. 234–241 (cit. on pp. 11, 32, 41, 68, 69).

[157] J. Roth, J. Eller, and F. N. Büchi. "Effects of Synchrotron Radiation on Fuel Cell Materials". *Journal of The Electrochemical Society* 159.8 (2012), F449–F455 (cit. on p. 74).

[158] B. P. Rynne and M. A. Youngson. "Linear Functional Analysis". *Springer Undergraduate Mathematics Series* (2008) (cit. on p. 53).

[159] M. Saadatfar, F. Garcia-Moreno, S. Hutzler, A. P. Sheppard, M. A. Knackstedt, J. Banhart, and D. Weaire. "Imaging of Metallic Foams Using X-ray micro-CT". *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 344.1-3 (2009), pp. 107–112 (cit. on pp. 21, 23).

[160] C. Saharia, J. Ho, W. Chan, T. Salimans, D. J. Fleet, and M. Norouzi. "Image Super-Resolution Via Iterative Refinement". *CoRR* (2021). arXiv: `2104.07636 [eess.IV]` (cit. on p. 119).

[161] M. Salamon, R. Hanke, P. Krüger, F. Sukowski, N. Uhlmann, and V. Voland. "Comparison of Different Methods for Determining the Size of a Focal Spot of Microfocus X-Ray Tubes". *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* 591.1 (2008), pp. 54–58 (cit. on p. 5).

[162] R. Schoonhoven, A. A. Hendriksen, D. M. Pelt, and K. J. Batenburg. "Lean: Graph-Based Pruning for Convolutional Neural Networks By Extracting Longest Chains". *CoRR* (2020). arXiv: `2011.06923 [cs.LG]` (cit. on p. 140).

[163] A.-K. Seghouane and Y. Saad. "Prewhitening High-Dimensional fMRI Data Sets Without Eigendecomposition". *Neural Computation* 26.5 (2014), pp. 907–919 (cit. on p. 60).

[164] P. Shearing, L. Howard, P. Jørgensen, N. Brandon, and S. Harris. "Characterization of the 3-dimensional Microstructure of a Graphite Negative Electrode From a Li-Ion Battery". *Electrochemistry Communications* 12.3 (2010), pp. 374–377 (cit. on p. 4).

[165] E. Shelhamer, J. Long, and T. Darrell. "Fully Convolutional Networks for Semantic Segmentation". *IEEE Transactions on Pattern Analysis and Machine Intelligence* 39.4 (2017), pp. 640–651 (cit. on p. 32).

[166] W. Shi, J. Caballero, F. Huszar, J. Totz, A. P. Aitken, R. Bishop, D. Rueckert, and Z. Wang. "Real-Time Single Image and Video Super-Resolution Using an Efficient Sub-Pixel Convolutional Neural Network". *2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR)* (2016) (cit. on pp. 13, 74).

[167] J.-B. Sibarita. "Deconvolution Microscopy". *Advances in Biochemical Engineering/Biotechnology* (2005), pp. 201–243 (cit. on pp. 45, 51, 71).

[168] E. Y. Sidky, J. H. Jørgensen, and X. Pan. "Convex Optimization Problem Prototyping for Image Reconstruction in Computed Tomography With the Chambolle-Pock Algorithm". *Physics in Medicine and Biology* 57.10 (2012), pp. 3065–3091 (cit. on pp. 10, 87, 92, 154).

[169] E. Y. Sidky and X. Pan. "Image Reconstruction in Circular Cone-Beam Computed Tomography By Constrained, Total-Variation Minimization". *Physics in Medicine and Biology* 53.17 (2008), pp. 4777–4807 (cit. on p. 23).

[170] S. Soltanayev and S. Y. Chun. "Training deep learning based denoisers without ground truth data". In: *Advances in Neural Information Processing Systems 31*. Curran Associates, Inc., 2018, pp. 3261–3271 (cit. on p. 46).

[171] Y. Song and S. Ermon. "Generative Modeling by Estimating Gradients of the Data Distribution". In: *Advances in Neural Information Processing Systems 32: Annual Conference on Neural Information Processing Systems 2019, NeurIPS 2019, December 8-14, 2019, Vancouver, BC, Canada*. Ed. by H. M. Wallach, H. Larochelle, A. Beygelzimer, F. d'Alché-Buc, E. B. Fox, and R. Garnett. 2019, pp. 11895–11907 (cit. on p. 119).

[172] M. Stampanoni, G. Borchert, P. Wyss, R. Abela, B. Patterson, S. Hunt, D. Vermeulen, and P. Rüegsegger. "High Resolution X-ray Detector for Synchrotron-Based Microtomography". *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* 491.1 (2002), pp. 291–301 (cit. on pp. 21, 22).

[173] S. Stock. *MicroComputed tomography : methodology and applications*. CRC Press, Taylor and Francis Group, 2020 (cit. on pp. 9, 73).

[174] Y. Sun, Z. Xia, and U. S. Kamilov. "Efficient and Accurate Inversion of Multiple Scattering With Deep Learning". *Optics Express* 26.11 (2018), p. 14678 (cit. on p. 45).

[175] C. Syben, M. Michen, B. Stimpel, S. Seitz, S. Ploner, and A. K. Maier. "Technical Note: Pyro-NN: Python Reconstruction Operators in Neural Networks". *Medical Physics* (2019) (cit. on p. 92).

[176] G. Tisson, P. Scheunders, and D. Van Dyck. "3D Region of Interest X-ray CT for Geometric Magnification From Multiresolution Acquisitions". *2nd IEEE International Symposium on Biomedical Imaging: Macro to Nano* (2004) (cit. on pp. 26, 30).

[177] D. Ulyanov, A. Vedaldi, and V. S. Lempitsky. "Deep Image Prior". *Int. J. Comput. Vis.* 128.7 (2020), pp. 1867–1888 (cit. on pp. 46, 60).

[178] A. van der Vaart. *Mathematische Statistiek*. 1995 (cit. on p. 7).

[179] G. Van Rossum and F. L. Drake Jr. *Python tutorial*. Centrum voor Wiskunde en Informatica, 1995 (cit. on p. 96).

[180] L. Varga and R. Mokso. "Iterative High Resolution Tomography From Combined High-Low Resolution Sinogram Pairs". *Combinatorial Image Analysis* (2018), pp. 150–163 (cit. on pp. 26, 30).

[181] S. Venkatakrishnan, A. Ziabari, J. Hinkle, A. W. Needham, J. M. Warren, and H. Z. Bilheux. "Convolutional Neural Network Based Non-Iterative Reconstruction for Accelerating Neutron Tomography". *Machine Learning: Science and Technology* 2.2 (2021), p. 025031 (cit. on p. 13).

[182] S. V. Venkatakrishnan, C. A. Bouman, and B. Wohlberg. "Plug-And-Play Priors for Model Based Reconstruction". *2013 IEEE Global Conference on Signal and Information Processing* (2013) (cit. on p. 48).

[183] R. Vescovi, M. Du, V. de Andrade, W. Scullin, D. Gürsoy, and C. Jacobsen. "Tomosaic: Efficient Acquisition and Reconstruction of Teravoxel Tomography Data Using Limited-Size Synchrotron X-ray Beams". *Journal of Synchrotron Radiation* 25.5 (2018), pp. 1478–1489 (cit. on p. 22).

[184] N. Viganò and W. Ludwig. "X-Ray Orientation Microscopy Using Topo-Tomography and Multi-Mode Diffraction Contrast Tomography". *Current Opinion in Solid State and Materials Science* 24.4 (2020), p. 100832 (cit. on pp. 20, 91, 104, 106).

[185] P. Virtanen, R. Gommers, T. E. Oliphant, M. Haberland, T. Reddy, D. Cournapeau, E. Burovski, P. Peterson, W. Weckesser, J. Bright, S. J. van der Walt, M. Brett, J. Wilson, K. Jarrod Millman, N. Mayorov, A. R. J. Nelson, E. Jones, R. Kern, E. Larson, C. Carey, İ. Polat, Y. Feng, E. W. Moore, J. Vand erPlas, D. Laxalde, J. Perktold, R. Cimrman, I. Henriksen, E. A. Quintero, C. R. Harris, A. M. Archibald, A. H. Ribeiro, F. Pedregosa, P. van Mulbregt, and S. 1. 0. Contributors. "SciPy 1.0–fundamental Algorithms for Scientific Computing in Python". *arXiv e-prints*, arXiv:1907.10121 (2019), arXiv:1907.10121. arXiv: `1907.10121 [cs.MS]` (cit. on p. 60).

[186] N. T. Vo, R. C. Atwood, M. Drakopoulos, and T. Connolley. "Data Processing Methods and Data Acquisition for Samples Larger Than the Field of View in Parallel-Beam Tomography". *Optics Express* 29.12 (2021), p. 17849 (cit. on p. 92).

[187] J. Vogel, F. Schaff, A. Fehringer, C. Jud, M. Wieczorek, F. Pfeiffer, and T. Lasser. "Constrained X-Ray Tensor Tomography Reconstruction". *Opt. Express* 23.12 (2015), pp. 15134–15151 (cit. on p. 107).

[188] N. Wadeson and M. Basham. "Savu: a Python-Based, MPI Framework for Simultaneous Processing of Multiple, N-Dimensional, Large Tomography Datasets". *CoRR* (2016). arXiv: `1610.08015 [cs.DC]` (cit. on pp. 92, 113).

[189] S. M. Walker, D. A. Schwyn, R. Mokso, M. Wicklein, T. Müller, M. Doube, M. Stampanoni, H. G. Krapp, and G. K. Taylor. "In Vivo Time-Resolved Microtomography Reveals the Mechanics of the Blowfly Flight Motor". *PLoS Biology* 12.3 (2014). Ed. by A. Hedenström, e1001823 (cit. on p. 74).

[190] C. Wang, U. Steiner, and A. Sepe. "Synchrotron Big Data Science". *Small* 14.46 (2018), p. 1802291 (cit. on pp. 4, 74).

[191] Z. Wang, A. Bovik, H. Sheikh, and E. Simoncelli. "Image Quality Assessment: From Error Visibility To Structural Similarity". *IEEE Transactions on Image Processing* 13.4 (2004), pp. 600–612 (cit. on pp. 34, 62).

[192] B. R. Whiting, P. Massoumzadeh, O. A. Earl, J. A. O'Sullivan, D. L. Snyder, and J. F. Williamson. "Properties of Preprocessed Sinogram Data in X-Ray Computed Tomography". *Medical Physics* 33.9 (2006), pp. 3290–3303 (cit. on pp. 8, 9).

[193] P. A. Witte, M. Louboutin, N. Kukreja, F. Luporini, M. Lange, G. J. Gorman, and F. J. Herrmann. "A Large-Scale Framework for Symbolic Implementations of Seismic Inversion Algorithms in Julia". *Geophysics* 84.3 (2019), F57–F71 (cit. on pp. 92, 113).

[194] Y. D. Witte, J. Vlassenbroeck, and L. van Hoorebeke. "A Multiresolution Approach To Iterative Reconstruction Algorithms in X-ray Computed Tomography". *IEEE Transactions on Image Processing* 19.9 (2010), pp. 2419–2427 (cit. on p. 26).

[195] H. Xu, S. Nagashima, H. P. Nguyen, K. Kishita, F. Marone, F. N. Büchi, and J. Eller. "Temperature Dependent Water Transport Mechanism in Gas Diffusion Layers Revealed By Subsecond Operando X-Ray Tomographic Microscopy". *Journal of Power Sources* 490 (2021), p. 229492 (cit. on p. 4).

[196] B. Yaman, S. A. H. Hosseini, S. Moeller, J. Ellermann, K. Uğurbil, and M. Akçakaya. "Self-supervised Learning of Physics-guided Reconstruction Neural Networks Without Fully Sampled Reference Data". *Magnetic Resonance in Medicine* (2020) (cit. on pp. 46, 74).

[197] S. Zabler, P. Cloetens, J.-P. Guigay, J. Baruchel, and M. Schlenker. "Optimization of Phase Contrast Imaging Using Hard X Rays". *Review of Scientific Instruments* 76.7 (2005), p. 073705 (cit. on pp. 45, 71).

[198] G. L. Zeng, Y. Li, and Q. Huang. "Analytic Time-Of-Flight Positron Emission Tomography Reconstruction: Two-Dimensional Case". *Visual Computing for Industry, Biomedicine, and Art* 2.1 (2019) (cit. on p. 45).

[199] K. Zhang, W. Zuo, Y. Chen, D. Meng, and L. Zhang. "Beyond a Gaussian Denoiser: Residual Learning of Deep CNN for Image Denoising". *IEEE Transactions on Image Processing* 26.7 (2017), pp. 3142–3155 (cit. on pp. 11, 47, 48, 50, 68, 69, 75).

[200] M. Zhussip, S. Soltanayev, and S. Y. Chun. "Extending Stein's unbiased risk estimator to train deep denoisers with correlated pairs of noisy images". In: *Advances in Neural Information Processing Systems 32*. Curran Associates, Inc., 2019, pp. 1465–1475 (cit. on p. 46).

[201] A. Ziabari, D. H. Ye, S. Srivastava, K. D. Sauer, J.-B. Thibault, and C. A. Bouman. "2.5D Deep Learning for CT Image Reconstruction Using a Multi-GPU Implementation". *2018 52nd Asilomar Conference on Signals, Systems, and Computers* (2018) (cit. on pp. 76, 79).

List of publications

"Talking..., if I were as good at everything as at talking..."

"Praten..., als ik alles zo zou kunnen als praten..."

Johan Cruijff,
Tiq, 1 March 1967

Publications that are part of this thesis:

1. A. A. Hendriksen, D. M. Pelt, W. J. Palenstijn, S. B. Coban, and K. J. Batenburg. "On-The-Fly Machine Learning for Improving Image Resolution in Tomography". *Applied Sciences* 9.12 (2019).

2. A. A. Hendriksen, D. M. Pelt, and K. J. Batenburg. "Noise2inverse: Self-Supervised Deep Convolutional Denoising for Tomography". *IEEE Transactions on Computational Imaging* (2020), pp. 1–1.

3. A. A. Hendriksen, M. Bührer, L. Leone, M. Merlini, N. Vigano, D. M. Pelt, F. Marone, M. di Michiel, and K. J. Batenburg. "Deep Denoising for Multi-Dimensional Synchrotron X-Ray Tomography Without High-Quality Reference Data". *Scientific Reports* 11.1 (2021).

4. A. A. Hendriksen, D. Schut, W. J. Palenstijn, N. Viganó, D. M. Kim Jisoo Pelt, T. van Leeuwen, and K. J. Batenburg. "Tomosipo: Fast, Flexible, and Convenient 3D Tomography for Complex Scanning Geometries in Python". *Optics Express* (2021).

Publications that are not part of this thesis:

1. A. Hendriksen, R. de Heide, and P. Grünwald. "Optional Stopping With Bayes Factors: a Categorization and Extension of Folklore Results, With an Application To Invariant Situations". *Bayesian Analysis* (2020).

2. A. Kostenko, W. Palenstijn, S. Coban, A. Hendriksen, R. van Liere, and K. Batenburg. "Prototyping X-Ray Tomographic Reconstruction Pipelines With Flexbox". *SoftwareX* 11 (2020), p. 100364.

3. M. J. Lagerwerf, A. A. Hendriksen, J.-W. Buurlage, and K. J. Batenburg. "Noise2Filter: Fast, Self-Supervised Learning and Real-Time Reconstruction for 3D Computed Tomography". *Machine Learning: Science and Technology* 2.1 (2020), p. 015012.

4. J. Minnema, M. Van Eijnatten, J. Wolff, A. A. Hendriksen, K. J. Batenburg, and T. Forouzanfar. "CT Image Segmentation for Additive Manufactured Skull Implants Using Deep Learning". en. *Transactions on Additive Manufacturing Meets Medicine* (2019), Vol 1 (2019): Trans. AMMM.

5. R. Schoonhoven, A. A. Hendriksen, D. M. Pelt, and K. J. Batenburg. "Lean: Graph-Based Pruning for Convolutional Neural Networks By Extracting Longest Chains". *CoRR* (2020). arXiv: `2011.06923 [cs.LG]`.

6. D. M. Pelt, A. A. Hendriksen, and K. J. Batenburg. "Foam-Like Phantoms for Comparing Tomography Algorithms". *Journal of Synchrotron Radiation* 29.1 (Jan. 2022).

7. M. Bührer, H. Xu, A. A. Hendriksen, F. N. Büchi, J. Eller, M. Stampanoni, and F. Marone. "Deep learning based classification of dynamic processes in time-resolved X-ray tomographic microscopy". *Scientific Reports* 11.1 (Dec. 2021).