#### Literature

Numerical Methods for Deep Learning

#### Literature Overview

- surveys on deep learning: [5, 30]
- some important works in deep learning:[37, 38, 31, 26, 35, 29, 27, 22, 23, 40, 32],
- ▶ applications of deep learning: natural language processing [13, 8, 28], image processing [31, 29], speech processing [24]
- approximation theory: [14, 25]
- ▶ PDE-inspired approaches to deep learning: [15, 18]
- optimization: [36, 17, 16, 34, 10, 6, 11]
- ▶ numerical methods: overview [3], optimization [33, 12, 4], linear algebra [39, 21], differential equations [2, 1], optimal control [9]
- ▶ classical work on adjoints ( $\approx$  backpropagation) [7]
- ▶ inverse problems: [19, 41, 20]

#### References

- U. Ascher. Numerical methods for Evolutionary Differential Equations. SIAM, Philadelphia, 2010.
- [2] U. Ascher and L. Petzold. Computer Methods for Ordinary Differential Equations and Differential-Algebraic Equations. SIAM, Philadelphia, PA, 1998.
- [3] U. M. Ascher and C. Greif. A First Course on Numerical Methods. SIAM, Philadelphia, 2011.
- [4] A. Beck. Introduction to Nonlinear Optimization. Theory, Algorithms, and Applications with MATLAB. SIAM, Philadelphia, Oct. 2014.
- [5] Y. Bengio et al. Learning deep architectures for Al. Foundations and trends® in Machine Learning, 2(1):1–127, 2009.
- [6] D. P. Bertsekas. Incremental Gradient, Subgradient, and Proximal Methods for Convex Optimization: A Survey. arXiv.org, July 2015.
- [7] G. A. Bliss. The use of adjoint systems in the problem of differential corrections for trajectories. *JUS Artillery*, 51:296–311, 1919.
- [8] A. Bordes, S. Chopra, and J. Weston. Question Answering with Subgraph Embeddings. arXiv preprint arXiv:1406.3676, 2014.
- [9] A. Borzì and V. Schulz. Computational optimization of systems governed by partial differential equations, volume 8. SIAM, Philadelphia, PA, 2012.
- [10] L. Bottou. Stochastic gradient descent tricks. Neural networks: Tricks of the trade, 2012.

- [11] L. Bottou, F. E. Curtis, and J. Nocedal. Optimization Methods for Large-Scale Machine Learning. arXiv.org, June 2016.
- [12] S. P. Boyd and L. Vandenberghe. *Convex Optimization*. Cambridge University Press, Mar. 2004.
- [13] R. Collobert, J. Weston, L. Bottou, M. Karlen, K. Kavukcuoglu, and P. Kuksa. Natural Language Processing (Almost) from Scratch. *Journal of Machine Learning Research*, 12:2493–2537, 2011.
- [14] G. Cybenko. Approximation by superpositions of a sigmoidal function. Mathematics of Control, Signals and Systems, 2(4):303–314, 1989.
- [15] W. E. A Proposal on Machine Learning via Dynamical Systems. Communications in Mathematics and Statistics, 5(1):1–11, Mar. 2017.
- [16] G. Golub and V. Pereyra. Separable nonlinear least squares: the variable projection method and its applications. *Inverse Problems*, 19:R1–R26, 2003.
- [17] G. H. Golub and V. Pereyra. The differentiation of pseudo-inverses and nonlinear least squares problems whose variables separate. SIAM Journal on Numerical Analysis, 10(2):413–432, 1973.
- [18] E. Haber and L. Ruthotto. Stable architectures for deep neural networks. *Inverse Problems*, 34:014004, 2017.
- [19] P. C. Hansen. Rank-deficient and discrete ill-posed problems. SIAM Monographs on Mathematical Modeling and Computation. Society for Industrial and Applied Mathematics (SIAM), Philadelphia, PA, 1998.

- [20] P. C. Hansen. Discrete inverse problems, volume 7 of Fundamentals of Algorithms. Society for Industrial and Applied Mathematics (SIAM), Philadelphia, PA, 2010.
- [21] P. C. Hansen, J. G. Nagy, and D. P. O'Leary. *Deblurring Images: Matrices, Spectra and Filtering*. Matrices, Spectra, and Filtering. Society for Industrial and Applied Mathematics (SIAM), Philadelphia, PA, 2006.
- [22] K. He, X. Zhang, S. Ren, and J. Sun. Deep residual learning for image recognition. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, pages 770–778, 2016.
- [23] K. He, X. Zhang, S. Ren, and J. Sun. Identity mappings in deep residual networks. In *European Conference on Computer Vision*, pages 630–645. Springer, 2016.
- [24] G. Hinton, L. Deng, D. Yu, G. E. Dahl, A.-r. Mohamed, N. Jaitly, A. Senior, V. Vanhoucke, P. Nguyen, T. N. Sainath, et al. Deep neural networks for acoustic modeling in speech recognition: The shared views of four research groups. *IEEE Signal Processing Magazine*, 29(6):82–97, 2012.
- [25] K. Hornik, M. Stinchcombe, and H. White. Multilayer feedforward networks are universal approximators. *Neural Networks*, 2(5):359–366, 1989.
- [26] G.-B. Huang, Q.-Y. Zhu, and C.-K. Siew. Extreme learning machine: Theory and applications. *Neurocomputing*, 70(1-3):489–501, Dec. 2006.
- [27] S. Ioffe and C. Szegedy. Batch Normalization: Accelerating Deep Network Training by Reducing Internal Covariate Shift. arXiv.org, 2015.

- [28] S. Jean, K. Cho, R. Memisevic, and Y. Bengio. On Using Very Large Target Vocabulary for Neural Machine Translation. arXiv preprint arXiv:1412.2007, 2014.
- [29] A. Krizhevsky, I. Sutskever, and G. Hinton. Imagenet classification with deep convolutional neural networks. Advances in neural information processing systems, 61:10971105, 2012.
- [30] Y. LeCun, Y. Bengio, and G. Hinton. Deep learning. *Nature*, 521(7553):436–444, 2015.
- [31] Y. LeCun, B. E. Boser, and J. S. Denker. Handwritten digit recognition with a back-propagation network. In *Advances in neural information processing systems*, pages 396–404, 1990.
- [32] H. Li, Z. Xu, G. Taylor, and T. Goldstein. Visualizing the Loss Landscape of Neural Nets. 2017.
- [33] J. Nocedal and S. Wright. *Numerical Optimization*. Springer Series in Operations Research and Financial Engineering. Springer Science & Business Media, New York, Dec. 2006.
- [34] D. P. O'Leary and B. W. Rust. Variable projection for nonlinear least squares problems. Computational Optimization and Applications. An International Journal, 54(3):579–593, 2013.
- [35] R. Raina, A. Madhavan, and A. Y. Ng. Large-scale deep unsupervised learning using graphics processors. In the 26th Annual International Conference, pages 873–880. ACM, June 2009.

- [36] H. Robbins and S. Monro. A Stochastic Approximation Method. The annals of mathematical statistics, 22(3):400–407, 1951.
- [37] F. Rosenblatt. The perceptron: A probabilistic model for information storage and organization in the brain. Psychological review, 65(6):386–408, 1958.
- [38] D. Rumelhart, G. Hinton, and J. Williams, R. Learning representations by back-propagating errors. *Nature*, 323(6088):533–538, 1986.
- [39] Y. Saad. Iterative Methods for Sparse Linear Systems. Second Edition. SIAM, Philadelphia, Apr. 2003.
- [40] D. Ulyanov, A. Vedaldi, and V. Lempitsky. Instance Normalization: The Missing Ingredient for Fast Stylization. arXiv.org, July 2016.
- [41] C. R. Vogel. Computational Methods for Inverse Problems. SIAM, Philadelphia, 2002.