

# References

- D. H. Ackley, G. E. Hinton and T. J. Sejnowski (1985). "A learning algorithm for Boltzmann machines." *Cognitive Science* **9**: 147–169.
- E. Alpaydin and C. Kaynak (1998). "Cascading Classifiers." *Kybernetika* **34**(4): 369–374.
- E. Anderson (1935). "The irises of the Gaspé Peninsula." *Bulletin of the American Iris Society* **59**: 2–5.
- A. Bain (1873). *Mind and Body: The Theories of Their Relation*. London, Henry King.
- P. V. Balakrishnan, M. C. Cooper, V. S. Jacob and P. A. Lewis. (1994). "A study of the classification capabilities of neural networks using unsupervised learning: A comparison with A-means clustering." *Psychometrika* **59**(4): 509–525.
- E. B. Baum and D. Haussler (1989). "What size net gives valid generalization." *Neural Computation* **1**(1): 151–160.
- W. G. Baxt and H. White (1995). "Bootstrapping confidence intervals for clinical input variable effects in a network trained to identify the presence of acute myocardial infarction." *Neural Computation* **7**(3): 624–638.
- S. Becker and Y. LeCun (1989). Improving the convergence of back-propagation learning with second order methods. *Proceedings of the 1988 Connectionist Summer School*. D. Touretzky, G. E. Hinton and T. Sejnowski. San Mateo, CA, Morgan Kaufmann Publishers: 29–37.
- R. E. Bellman (1961). *Adaptive Control Processes: A Guided Tour*. Princeton, NJ, Princeton University Press.
- L. M. Belue and K. W. Bauer, Jr. (1995). "Determining input features for multilayer perceptrons." *Neurocomputing* **7**(2): 1A–121.
- D. P. Bertsekas and J. Tsitsiklis (1996). *Neuro-Dynamic Programming*. Belmont, MA, Athena Scientific.
- M. Bianchini and M. Gori (1996). "Optimal Learning in Artificial Neural Networks: A Review of Theoretical Results." *Neurocomputing* **13**(5): 313–346.
- C. M. Bishop (1995). *Neural Networks for Pattern Recognition*. Oxford, Oxford University Press.
- C. L. Blake and C. J. Merz (1998). UCI Repository of machine learning databases. Irvine, CA, University of California, Department of Information and Computer Science: <http://www.ics.uci.edu/~mllearn/MLRepository.html>.

- L. Breiman (1996). "Heuristics of instability and stabilization in model selection." *Annals of Statistics* **24**(6): 2350–2383.
- L. Breiman, J. H. Friedman, R. A. Olshen and C. J. Stone (1984). *Classification and Regression Trees*, Kluwer Academic Publishers.
- L. Breiman and P. Spector (1992). "Submodel selection and evaluation in regression: The X-random case." *International Statistical Review* **60**(3): 291–319.
- J. S. Bridle (1990). Training Stochastic Model Recognition Algorithms as Networks can lead to Maximum Mutual Information Estimation of Parameters. *Advances in Neural Information Processing Systems*. D. S. Touretzky. San Mateo, CA, Morgan Kaufmann Publishers. **2**: 2A–217.
- H. B. Burke (1996). The Importance of Artificial Neural Networks in Biomedicine. *Applications of Neural Networks in Environment, Energy, and Health*. P. E. Keller, S. Hashem, L. J. Kangas and R. T. Kouzes. Singapore, World Scientific Publishing: 145–153.
- C. Cardaliaguet and E. Guillaume (1992). "Approximation of a function and its derivative with a neural network." *Neural Networks* **5**(2): 207–220.
- G. A. Carpenter (1997). "Distributed learning, recognition, and prediction by ART and ARTMAP neural networks." *Neural Networks* **10**(8): 1473–1494.
- G. A. Carpenter and S. Grossberg (1987a). "A massively parallel architecture for a self-organizing neural pattern recognition machine." *Computer Vision, Graphics, and Image Processing* **37**(1): 54–115.
- G. A. Carpenter and S. Grossberg (1987b). "ART2: Stable self-organization of pattern recognition codes for analog input patterns." *Applied Optics* **26**(23): 4919–4930.
- G. A. Carpenter and S. Grossberg (1990). ART3: Self-organization of Distributed Pattern Recognition Codes in Neural Network Hierarchies. *Proceedings of the International Conference on Neural Networks (INNC'90)*. Amsterdam, Kluwer Academic Publishers, North-Holland. **2**: 801–804.
- G. A. Carpenter, S. Grossberg, N. Markuzon, J. H. Reynolds and D. B. Rosen (1992). "Fuzzy ARTMAP: A Neural Network Architecture for Incremental Supervised Learning of Analog Multidimensional Maps." *IEEE Transactions on Neural Networks* **3**(5): 698–713.
- G. A. Carpenter, S. Grossberg and J. H. Reynolds (1995). "A Fuzzy ARTMAP Nonparametric Probability Estimator for Nonstationary Pattern Recognition Problems." *IEEE Transactions on Neural Networks* **6**(6): 1330–1336.
- G. A. Carpenter, S. Grossberg and D. B. Rosen (1991). "Fuzzy ART: Fast Stable Learning and Categorization of Analog Patterns by an Adaptive Resonance Systems." *Neural Networks* **4**(6): 759–771.
- G. A. Carpenter and W. D. Ross (1995). "ART-EMAP: A Neural Network Architecture for Object Recognition by Evidence Accumulation." *IEEE Transactions on Neural Networks* **6**(4): 805–818.
- T. P. Caudell, S. D. G. Smith, R. Escobedo and M. Anderson (1994). "NIRS: Large Scale ART-1 Neural Architectures for Engineering Design Retrieval." *Neural Networks* **7**(9): 1339–1350.

- L.-W. W. Chan and F. Fallside (1987). "An adaptive training algorithm for back-propagation networks." *Computer Speech and Language* **2**: 205–218.
- T. Chen and H. Chen (1995). "Universal Approximation to Nonlinear Operators by Neural Networks with Arbitrary Activation Functions and Its Application to Dynamical Systems." *IEEE Transactions on Neural Networks* **6**(4): 9A–917.
- G. Copson, R. Badcock, J. Boon and P. Britton (1997). "Articulating a systematic approach to clinical crime profiling." *Criminal Behaviour and Mental Health* **7**: 13–17.
- T. M. Cover (1965). "Geometrical and statistical properties of systems of linear inequalities with applications in pattern recognition." *IEEE Transactions on Electronic Computers* **E3-14**(3): 326–334.
- G. Coward (1992). *Tree Book: Learning to Recognize Trees of British Columbia*. Victoria, BC, Canada, Forestry Canada.
- N. Cristianini and J. Shawe-Taylor (2000). *An Introduction to Support Vector Machines*. Cambridge, Cambridge University Press.
- G. V. Cybenko (1989). "Approximation by Superpositions of a Sigmoidal Function." *Mathematics of Control, Signals, and Systems* **2**(4): 303–314.
- H. Dai and C. Macbeth (1997). "Effects of learning parameters on learning procedure and performance of a BPNN." *Neural Networks* **10**(8): 1505–1521.
- J. S. Denker and Y. LeCun (1991). Transforming Neural-Net Output Levels to Probability Distributions. *Advances in Neural Information Processing Systems*. R. Lippmann, J. E. Moody and D. S. Touretzky. San Mateo, CA, Morgan Kaufmann Publishers. **3**: 853–859.
- H. Drucker and Y. LeCun (1992). "Improving Generalization Performance Using Double Backpropagation." *IEEE Transactions on Neural Networks* **3**(6): 991–997.
- H. Drucker, D. Wu and V. N. Vapnik (1999). "Support Vector Machines for Spam Categorization." *IEEE Transactions on Neural Networks* **10**(5): 1048–1054.
- R. O. Duda and P. E. Hart (1973). *Pattern Analysis and Scene Classification*. New York, John Wiley & Sons.
- R. O. Duda, P. E. Hart and D. G. Stork (2001). *Pattern Classification, 2nd Edition*. New York, John Wiley & Sons Inc.
- R. Eckhorn, H. J. Reitboeck, M. Arndt and P. Dicke (1990). "Feature linking via synchronization among distributed assemblies: Simulations of results from cat visual cortex." *Neural Cooperativity* **2**(3): 293–307.
- B. Efron (1979). "Bootstrap methods: Another look at the jackknife." *Annals of Statistics* **7**(1): 1–26.
- B. Efron (1982). *The Jackknife, the Bootstrap and Other Resampling Plans*. Philadelphia, Society for Industrial and Applied Mathematics.
- B. Efron (1983). "Estimating the error rate of a prediction rule: Improvement on cross-validation." *Journal of the American Statistical Association* **78**: 316–331.
- B. Efron and R. Tibshiran (1986). "Bootstrap methods for standard errors, confidence intervals, and other measures of statistical accuracy." *Statistical Science* **1**: 54–77.

- B. Efron and R. J. Tibshirani (1993). *An Introduction to the Bootstrap*. London, Chapman & Hall.
- B. Efron and R. J. Tibshirani (1997). "Improvements on cross-validation: The .632+ bootstrap method." *Journal of the American Statistical Association* **92**: 548–560.
- J. L. Elman (1991). "Distributed representations, simple recurrent networks, and grammatical structure." *Machine Learning* **7**: 195–225.
- S. E. Fahlman (1989). Faster Learning Variations on Back Propagation: An Empirical Study. *Proceedings of the 1988 Connectionist Models Summer School*. D. Touretzky, G. E. Hinton and T. Sejnowski. San Mateo, CA, Morgan Kaufmann Publishers: 38–51.
- S. E. Fahlman and C. Liebiere (1990). The Cascade—Correlation Learning Architecture. *Advances in Neural Information Processing Systems*. D. S. Touretzky. San Mateo, CA, Morgan Kaufmann Publishers. **2**: 524–532.
- B. G. Farley (1960). Self-Organizing Models for Learned Perception. *Self-Organizing Systems*. M. C. Yovits and S. Cameron. Oxford, UK, Pergamon Press.
- B. G. Farley and W. A. Clark (1954). "Simulation of Self-Organizing Systems by Digital Computer." *IRE Transactions on Information Theory* **4**(4): 76–84.
- B. G. Farley and W. A. Clark (1955). Generalization of pattern recognition in a self-organizing system. *Proceedings of the 1955 Western Joint Computer Conference*: 86–91.
- R. A. Fisher (1936). "The use of multiple measurements in taxonomic problems." *Annual Eugenics* **7**(Part II): 179–188.
- D. Fogel (1990). "An Information Criterion for Optimal Neural Network Selection." *IEEE Transactions on Neural Networks* **2**(5): 490–497.
- D. H. Foley (1972). "Considerations of Sample and Feature Size." *IEEE Transactions on Information Theory* **IT-18**(5): 618–626.
- N. Fraser (1998). Neural Network Follies. <http://neil.fraser.name/writing/tank/>.
- B. R. Frieden (1983). *Probability, Statistical Optics, and Data Testing*. Berlin Heidelberg New York, Springer-Verlag.
- K. Fukunaga (1990). *Introduction to Statistical Pattern Recognition*. San Diego, CA, Academic Press, Inc.
- K. Funahashi (1989). "On the approximate realization of continuous mappings by neural networks." *Neural Networks* **2**(3): 183–192.
- V. J. Geberth (1996). *Practical Homicide Investigation: Tactics, Procedures, and Forensic Techniques*. Boca Raton, Florida, CRC Publishing.
- K. A. Gernoth and J. W. Clark (1995). "Neural Networks That Learn to Predict Probabilities: Global Models of Nuclear Stability and Decay." *Neural Networks* **8**(2): 291–311.
- G. R. Gindi, A. F. Gmitro and K. Parthasarathy (1988). "Hopfield Model Associative Memory with Nonzero-Diagonal Terms in Memory Matrix." *Applied Optics* **27**(1): 129–134.

- A. F. Gmitro, P. E. Keller and G. R. Gindi (1989). "Statistical performance of outer-product associative memory models." *Applied Optics* **28**(10): 1940–1948.
- C. Goutte (1997). "Note on free lunches and cross-validation." *Neural Computation* **9**(6): 12A–1215.
- S. Grossberg (1976a). "Adaptive pattern classification and universal recording: I. Parallel development and coding of neural detectors." *Biological Cybernetics* **23**: 121–134.
- S. Grossberg (1976b). "On the Development of Feature Detectors in the Visual Cortex with Applications to Learning and Reaction-Diffusion Systems." *Biological Cybernetics* **21**(3): 145–159.
- S. Grossberg (1976c). "Adaptive pattern classification and universal recording: II. Feedback, expectation, olfaction, illusions." *Biological Cybernetics* **23**: 187–202.
- S. Grossberg (1987). *The Adaptive Brain I: Cognition, Learning, Reinforcement, and Rhythm*. Amsterdam, Elsevier/North-Holland.
- M. Hagiwara (1992). Theoretical derivation of momentum term in back-propagation. *Proceedings of the International Joint Conference on Neural Networks (IJCNN'92)*. Piscataway, NJ, IEEE. **1**: 682–686.
- C. L. Harris and J. L. Elman (1989). Representing variable information with simple recurrent networks. *Proceedings of the Tenth Annual Conference of the Cognitive Science Society*. Hillsdale, NJ, Lawrence Erlbaum: 635–642.
- D. Harrison, Jr. and D. L. Rubinfeld (1978). "Hedonic housing prices and the demand for clean air." *Journal of Environmental Economics and Management* **5**(1): 81–102.
- S. Haykin (1994). *Neural Networks: A Comprehensive Foundation*. New York, Macmillan College Publishing Company.
- M. A. Hearst, B. Scholkopf, S. Dumais, E. Osuna and J. Platt (1998). "Trends and Controversies: Support Vector Machines." *IEEE Intelligent Systems* **13**(4): 18–28.
- D. O. Hebb (1949). *The Organization of Behavior*. New York, John Wiley & Sons.
- R. Hecht-Nielsen (1987). "Counterpropagation networks." *Applied Optics* **26**(23): 4979–4983.
- J. S. U. Hjorth (1994). *Computer Intensive Statistical Methods Validation, Model Selection, and Bootstrap*. London, Chapman & Hall.
- A. L. Hodgkin and A. F. Huxley (1952). "A Quantitative Description of Membrane Current and its Application to Conduction and Excitation in Nerve." *Journal of Physiology* **117**: 500–544.
- J. J. Hopfield (1982). "Neural networks and physical systems with emergent collective computational abilities." *Proceedings of the National Academy of Sciences USA* **79**: 2554–2558.
- J. J. Hopfield (1984). "Neurons with graded response have collective computational properties like those of two-state neurons." *Proceedings of the National Academy of Sciences USA* **81**: 3088–3092.

- J. J. Hopfield and D. W. Tank (1985). “‘Neural’ computation of decisions in optimization problems.” *Biological Cybernetics* **52**: 141–152.
- J. J. Hopfield and D. W. Tank (1986). “Computing with neural circuits: A model.” *Science* **233**: 625–633.
- K. Hornik, M. Stinchcombe and H. White (1989). “Multilayer feedforward networks are universal approximators.” *Neural Networks* **2**: 359–366.
- H. Hotelling (1933). “Analysis of a complex of statistical variables into principal components.” *Journal of Educational Psychology* **24**: 417–441 and 498–520.
- J. Huang, M. Georgiopoulos and G. L. Heileman (1995). “Fuzzy ART Properties.” *Neural Networks* **8**(2): 203–213.
- S.-C. Huang and Y.-F. Huang (1990). “Learning Algorithms for Perceptrons Using Back Propagation with Selective Updates.” *IEEE Control Systems Magazine* **10**(3): 56–61.
- C.-A. Hung and S.-F. Lin (1995). “Adaptive Hamming Net: A Fast-Learning ART 1 Model Without Searching.” *Neural Networks* **8**(4): 605–618.
- B. Hunt, M. S. Nadar, P. Keller, E. VonColln and A. Goyal (1993). “Synthesis of a Nonrecurrent Associative Memory Model Based on a Nonlinear Transformation in the Spectral Domain.” *IEEE Transactions on Neural Networks* **4**(5): 873–878.
- C. M. Hurvich and C.-L. Tsai (1989). “Regression and time series model selection in small samples.” *Biometrika* **76**: 297–307.
- D. R. Hush and B. G. Horne (1993). “Progress in Supervised Neural Networks: What’s New Since Lippmann?” *IEEE Signal Processing Magazine* **10**(1): 8–39.
- A. Hyvärinen and E. Oja (1999). Independent Component Analysis: A Tutorial. <http://www.cis.hut.fi/~aapo/ps/NN00.pdf>. Espoo, Finland, Helsinki University of Technology.
- A. Hyvärinen and E. Oja (2000). “Independent Component Analysis: Algorithms and Applications.” *Neural Networks* **13**(4-5): 4A–430.
- J. E. Jackson (1991). *A User’s Guide to Principal Components*. New York, John Wiley & Sons Inc.: 63–69.
- R. A. Jacobs (1988). “Increased Rates of Convergence Through Learning Rate Adaptation.” *Neural Networks* **1**(4): 295–307.
- W. James (1890). *Principles of Psychology*. New York, Henry Holt.
- D. S. Johnson and C. H. Papadimitriou (1985). Computational Complexity. *The Traveling Salesman Problem*. E. L. Lawler, J. K. Lenstra, A. H. G. Rinnooy Kan and D. B. Shmoys. New York, John-Wiley & Sons: 37–85.
- B. L. Kalman and S. C. Kwasny (1992). Why Tanh: Choosing a Sigmoidal Function. *Proceedings of the International Joint Conference on Neural Networks (IJCNN’92)*. Piscataway, NJ, IEEE. **4**: 578–581.
- L. J. Kangas, K. M. Terrones, R. D. Keppel and R. D. La Moria (1998). Computer Aided Tracking and Characterization of Homicides & Sexual Assaults (CATCH). *Applications and Science of Computational Intelligence II—Proceedings of the SPIE*. K. L. Priddy, P. E. Keller, D. B. Fogel and J. C. Bezdek. Bellingham, WA, SPIE. **3722**: 250–260.

- P. P. Kanjilal and D. N. Banerjee (1995). "On the Application of Orthogonal Transformation for the Design and Analysis of Feedforward Networks." *IEEE Transactions on Neural Networks* **6**(5): 1061–1070.
- M. Kearns (1997). "A bound on the error of cross validation using the approximation and estimation rates, with consequences for the training-test split." *Neural Computation* **9**(5): 1143–1161.
- P. E. Keller and A. D. McKinnon (1999). Pulse-Coupled Neural Networks for Medical Image Analysis. *Applications and Science of Computational Intelligence II—Proceedings of the SPIE*. K. L. Priddy, P. E. Keller, D. B. Fogel and J. C. Bezdek. Bellingham, WA, SPIE. **3722**: 444–451.
- P. E. Keller, D. L. McMakin, D. M. Sheen, A. D. McKinnon and J. W. Summet (2000). Privacy Algorithm for Airport Passenger Screening Portal. *Applications and Science of Computation Intelligence III – Proceedings of the SPIE*. K. L. Priddy, P. E. Keller and D. B. Fogel. Bellingham, WA, SPIE. **4055**: 476–483.
- R. D. Keppel and R. Walter (1999). "Profiling Killers: A Revised Classification Model for Understanding Sexual Murder." *International Journal of Offender Therapy and Comparative Criminology* **43**(4): 417–437.
- R. Kohavi (1995). A study of cross-validation and bootstrap for accuracy estimation and model selection. *Proceedings of the International Joint Conference on Artificial Intelligence (IJCAI'95)*. San Mateo, CA, Morgan Kaufmann Publishers: 1137–1143.
- T. Kohonen (1972). "Correlation Matrix Memories." *IEEE Transactions on Computers* **3-21**: 353–359.
- T. Kohonen (1982). "Self-organized formation of topologically correct feature maps." *Biological Cybernetics* **43**: 59–69.
- T. Kohonen (1987). "Adaptive, associative, and self-organizing functions in neural computing." *Applied Optics* **26**(23): 4910–4918.
- T. Kohonen (1988). "The 'Neural' Phonetic Typewriter." *IEEE Computer Magazine* **21**(3): A-22.
- T. Kohonen (1989). *Self-Organization and Associative Memory*. Berlin Heidelberg London, Springer-Verlag.
- B. Kosko (1987). "Constructing an associative memory." *Byte* **12**(10): 137–144.
- B. Kosko (1987). "Adaptive bidirectional memories." *Applied Optics* **26**(23): 4947–4960.
- B. Kosko (1988). "Bidirectional associative memory." *IEEE Transactions on Systems, Man and Cybernetics* **SM3-18**(1): 49–60.
- B. Kosko (1992). *Neural Networks for Signal Processing*. Upper Saddle River, NJ, Prentice Hall.
- A. Kowalczyk (1997). "Estimates of storage capacity of multilayer perceptron with threshold logic hidden units." *Neural Networks* **10**(8): 1417–1433.
- M. A. Kraaijveld, J. Mao and A. K. Jain (1995). "A Nonlinear Projection Method Based on Kohonen's Topology Preserving Maps." *IEEE Transactions on Neural Networks* **6**(3): 548–559.

- A. H. Kramer and A. L. Sangiovanni-Vincentelli (1989). Efficient parallel learning algorithms for neural networks. *Advances in Neural Information Processing Systems*. D. S. Touretzky. San Mateo, CA, Morgan Kaufmann Publishers. **1**: 40–48.
- Y. LeCun (1985). Une procedure d'apprentissage pour reseau a seuil assymetrique. *Cognitiva '85: A la frontiere de l'intelligence Artificielle des Sciences de la Connaissance des Neurosciences*: 599–604.
- G. G. Lendaris, K. Mathia and R. E. Saeks (1999). "Linear Hopfield Networks and Constrained Optimization." *IEEE Transactions of Systems, Man & Cybernetics* **29**(1): 114–118.
- K. Levenberg (1944). "A method for the solution of certain problems in least squares." *Quart. Applied Mathematics* **2**: 164–168.
- T. Linblad and J. M. Kinser (1998). *Image Processing using Pulse-Coupled Neural Networks*. London, Springer.
- R. Lippmann (1987). "An Introduction to Computing with Neural Networks." *IEEE ASSP Magazine* **4**(2): 4–22.
- P. C. Mahalanobis (1936). "On the generalized distance in statistics." *Proceedings of the National Institute of Science of India* **2**: 49–53.
- O. L. Mangasarian and D. R. Musicant (1999). "Successive Overrelaxation for Support Vector Machines." *IEEE Transactions on Neural Networks* **10**(5): 1032–1037.
- J. Mao and A. K. Jain (1996). "A Self-Organizing Network for Hyperellipsoidal Clustering (HEC)." *IEEE Transactions on Neural Networks* **7**(1): 16–29.
- D. W. Marquardt (1963). "An algorithm for least-squares estimation of nonlinear parameters." *Journal of the Society of Industrial Applied Mathematics* **11**: 431–441.
- S. Marriott and R. F. Harrison (1995). "A Modified Fuzzy ARTMAP Architecture for the Approximation of Noisy Mappings." *Neural Networks* **8**(4): 619–641.
- T. Masters (1995). *Advanced Algorithms for Neural Networks: A C++ Sourcebook*. New York, John Wiley & Sons.
- W. S. McCulloch and W. H. Pitts (1943). "A Logical Calculus of the Ideas Imminent in Nervous Activity." *Bulletin of Mathematical Biophysics* **5**: 115–133.
- R. J. McEliece, E. C. Posner, E. R. Rodemich and S. S. Venkates (1987). "The capacity of the Hopfield associative memory." *IEEE Transactions on Information Theory* **33**(4): 461–482.
- R. G. Miller (1974). "The jackknife, a review." *Biometrika* **61**: 1–15.
- M. L. Minsky and S. A. Papert (1969). *Perceptrons: An introduction to Computational Geometry*. Cambridge, MA, MIT Press.
- C. Z. Mooney and R. D. Duval (1993). *Bootstrapping: A Nonparametric Approach to Statistical Inference*, Sage Publications.
- B. Moore (1988). ART 1 and Pattern Clustering. *Proceedings of the 1988 Connectionist Summer School*. D. Touretzky, G. E. Hinton and T. Sejnowski. San Mateo, CA, Morgan Kaufmann Publishers: 174–185.



- F. M. Mulier and V. S. Cherkassky (1995). "Statistical Analysis of Self-organization." *Neural Networks* **8**(5): 717–727.
- I. Nabney (2002). *Netlab: Algorithms for Pattern Recognition*. Berlin Heidelberg London, Springer-Verlag.
- T. Nitta (1997). "An extension of the back-propagation algorithm to complex numbers." *Neural Networks* **10**(8): 1391–1415.
- E. Oja (1991). Data compression, feature extraction, and auto-association in feed-forward neural networks. *Proceedings of the 1991 International Conference on Artificial Neural Networks (ICANN'91)*. T. Kohonen, K. Makisara, O. Simula and J. Kangas. Amsterdam, Elsevier Science Publishers B. V. **1**: 737–746.
- E. Oja (1991). "A simplified neuron model as a principal component analyzer." *Journal of Mathematical Biology* **15**: 267–273.
- Y.-H. Pao (1989). *Adaptive Pattern Recognition and Neural Networks*. Reading, MA, Addison-Wesley Publishing Company, Inc.
- D. Parker (1982). Learning-logic. *Invention Report S81-64, File 1*. Palo Alto, CA, Stanford University, Office of Technology Licensing.
- M. Plutowski, S. Sakata and H. White (1994). Cross-validation estimates IMSE. *Advances in Neural Information Processing Systems*. J. D. Cowan, G. Tesauro and J. Alspector. San Mateo, CA, Morgan Kaufmann Publishers. **6**: 391–398.
- T. Poggio (1975). "On optimal nonlinear associative recall." *Biological Cybernetics* **19**: 201–209.
- B. T. Poljak (1964a). О некоторых способах ускорения сходимости итерационных методов." *Журн. выч. мат. и мат. физ. — Zhurnal Vychislitel'noi Matematiki I Matematicheskoi Fiziki* **4**(5): 791–803.
- B. T. Poljak (1964b). "Some methods of speeding up the convergence of iteration methods." *USSR Computational Mathematics and Mathematical Physics* **4**(5): 1–17.
- K. L. Priddy, S. K. Rogers, D. W. Ruck, G. L. Tarr and M. Kabrisky (1993). "Bayesian selection of important features for feedforward neural networks." *Neurocomputing* **5**(2): 91–103.
- K.L. Priddy (2004). "A comparative analysis of machine classifiers." *Intelligent Computing: Theory and Applications II, Proceedings of SPIE*. K. L. Priddy. Bellingham, WA, SPIE. **5421**: 142–148.
- M. H. Quenouille (1949). "Approximate tests of correlation in time series." *Journal of the Royal Statistical Society B* **11**: 18–84.
- M. H. Quenouille (1956). "Notes on bias reduction." *Biometrika* **43**: 353–360.
- S. Raudys (2000). "How Good are Support Vector Machines?" *Neural Networks* **13**(1): 17–19.
- S. Raudys (2001). *Statistical and Neural Classifiers: An Integrated Approach to Design*. Berlin Heidelberg London, Springer-Verlag.
- B. D. Ripley (1996). *Pattern Recognition and Neural Networks*. Cambridge, Cambridge University Press.
- N. Rochester, J. H. Holland, H. L. H. and W. L. Duda (1956). "Tests on a Cell Assembly Theory of the Action of the Brain Using a Large Digital Computer." *IRE Transactions on Information Theory* **IT-2**(3): 80–93.

- S. K. Rogers (1997). Tools for Pattern Recognition. *EENG 617 Class Handout*. Wright-Patterson AFB, OH, Air Force Institute of Technology.
- F. Rosenblatt (1958). "The Perceptron: a Probabilistic Model for Information Storage and Organization in the Brain." *Psychological Review* **65**: 386–408.
- F. Rosenblatt (1959). *Principles of Neurodynamics*. New York, Spartan Books.
- W. A. Rosenblith and H. B. Barlow (1990). "Sensory communications." *Scientific American*.
- D. W. Ruck, S. K. Rogers and M. Kabrisky (1990a). "Feature selection using a multilayer perceptron." *Journal of Neural Network Computing* **2**(2): 40–48.
- D. W. Ruck, S. K. Rogers, M. Kabrisky, M. E. Oxley and B. S. Suter (1990b). "The Multilayer Perceptron as an Approximation to a Bayes Optimal Discriminant Function." *IEEE Transactions on Neural Networks* **1**(4): 296–298.
- D. E. Rumelhart, G. E. Hinton and R. J. Williams (1986). Learning internal representations by error propagation. *Parallel Distributed Processing: Explorations in the Microstructures of Cognition. 1: Foundations*. D. E. Rumelhart and J. L. McClelland. Cambridge, MA, MIT Press. **1**: 318–362.
- T. D. Sanger (1989a). An optimality principle for unsupervised learning. *Advances in Neural Information Processing Systems*. D. S. Touretzky. San Mateo, CA, Morgan Kaufmann Publishers. **1**: A–19.
- T. D. Sanger (1989b). "Optimal unsupervised learning in a single-layer linear feed-forward neural network." *Neural Networks* **2**(6-7): 459–473.
- T. J. Sejnowski and C. R. Rosenberg (1987). "Parallel Networks that Learn to Pronounce English Text." *Complex Systems* **1**: 145–168.
- J. Shao (1993). "Linear model selection by cross-validation." *Journal of the American Statistical Association* **88**: 486–494.
- J. Shao (1997). "An asymptotic theory for linear model selection." *Statistica Sinica* **7**: 221–264.
- J. Shao and D. Tu (1995). *The Jackknife and Bootstrap*. Berlin Heidelberg London, Springer-Verlag.
- T. A. B. Snijders (1988). On cross-validation for predictor evaluation in time series. *On Model Uncertainty and Its Statistical Implications*. T. K. Dijkstra. Berlin, Springer-Verlag: 56–69.
- F. Stäger and M. Agarwal (1997). "Three methods to speed up the training of feed-forward and feedback perceptrons." *Neural Networks* **10**(8): 1435–1443.
- M. Stone (1977). "Asymptotics for and against cross-validation." *Biometrika* **64**: 29–35.
- M. Stone (1979). "Comments on model selection criteria of Akaike and Schwarz." *Journal of the Royal Statistical Society, Series B* **41**: 276–278.
- W. S. Stornetta and B. A. Huberman (1987). An Improved Three-Layer, Back Propagation Algorithm. *Proceedings of the IEEE Conference on Neural Networks (ICNN'87)*. Piscataway, NJ, IEEE. **2**: 637–644.
- Y. Suzuki (1995). "Self-Organizing QRS-Wave Recognition in ECG Using Neural Networks." *IEEE Transactions on Neural Networks* **6**(6): 1469–1477.

- D. W. Tank and J. J. Hopfield (1986). "Simple Neural Optimization Networks: An A/D Converter, Signal Decision Circuit, and a Linear Programming Circuit." *IEEE Transactions on Circuits and Systems* **33**(5): 533–541.
- G. Tarr, K. Priddy and S. Rogers (1992). "NeuralGraphics: A general purpose environment for neural network simulation," *Applications of Artificial Neural Networks III, Proceedings of SPIE*. S. K. Rogers Bellingham, WA, SPIE. **1709**: 1047–1056.
- R. Tibshirani (1996). "A comparison of some error estimates for neural network models." *Neural Computation* **8**: 152–163.
- J. W. Tukey (1958). "Bias and Confidence in Not-Quite Large Samples." *Annals of Mathematical Statistics* **29**: 614.
- V. N. Vapnik (1995). *The Nature of Statistical Learning Theory*. Berlin Heidelberg London, Springer-Verlag.
- B. Verma (1997). "Fast Training of Multilayer Perceptrons." *IEEE Transactions on Neural Networks* **8**(6): 1314–1320.
- R. Vitthal, P. Sunthar and C. D. Rao (1995). "The Generalized Proportional-Integral-Derivative (PID) Gradient Descent Back Propagation Algorithm." *Neural Networks* **8**(4): 563–569.
- S. Watanabe and K. Fukumizu (1995). "Probabilistic Design of Layered Neural Networks Based on Their Unified Framework." *IEEE Transactions on Neural Networks* **6**(3): 691–702.
- S. M. Weiss and C. A. Kulikowski (1991). *Computer Systems That Learn*. San Mateo, CA, Morgan Kaufmann Publishers.
- P. J. Werbos (1974). "Beyond Regression: New Tools for Prediction and Analysis in the Behavioral Sciences." Ph.D. Thesis, Cambridge, MA.
- P. J. Werbos (1994). *The Roots of Backpropagation*. New York, John Wiley & Sons.
- B. Widrow (1962). Generalization and information Storage in Networks of Adaline Neurons. *Self-Organizing Systems*. M. C. Yovits, G. T. Jacobi and G. D. Goldstein. Washington, D.C., Spartan Books.
- B. Widrow and M. E. Hoff, Jr. (1960). Adaptive Switching Circuits. *1960 IRE WESCON Convention Record, Part 4*. New York, Institute of Radio Engineers: 96–104.
- B. Widrow and M. A. Lehr (1990). "30 Years of Adaptive Neural Networks: Perceptron, Madaline, and Backpropagation." *Proceedings of the IEEE* **78**: 1415–1441.
- A. L. Wilkes and N. J. Wade (1997). "Bain on Neural Networks." *Brain and Cognition* **33**: 295–305.
- R. J. Williams and D. Zipser (1989). "A learning algorithm for continually running fully recurrent neural networks." *Neural Computation* **1**(2): 270–280.
- R. J. Williams and D. Zipser (1990). Gradient-based learning algorithms for recurrent connectionist networks. *Technical Report NU-CCS-90-9*. Boston, Northeastern University, College of Computer Science.
- R. J. Williams and D. Zipser (1995). Gradient-Based Learning Algorithms for Recurrent Networks and Their Computational Complexity. *Backpropagation:*

- Theory, Architectures, and Applications*. Y. Chauvin and D. E. Rumelhart. Hillsdale, NJ, Lawrence Erlbaum Publishers: 433–486.
- J. R. Williamson (1996). “Gaussian ARTMAP: A neural network for fast incremental learning of noisy multidimensional maps.” *Neural Networks* **9**(5): 881–897.
- G. V. Wilson and G. S. Pawley (1988). “On the stability of the traveling salesman problem algorithm of Hopfield and Tank.” *Biological Cybernetics* **58**(1): 63–70.
- Y. Zheng and J. F. Greenleaf (1996). “The Effect of Concave and Convex Weight Adjustments on Self-Organizing Maps.” *IEEE Transactions on Neural Networks* **7**(1): 87–96.
- H. Zhu and R. Rohwer (1996). “No free lunch for cross-validation.” *Neural Computation* **8**(7): 1421–1426.

# Index

- a priori* probability, 94
- activation function, 108, 114–115
- Adaptive linear element, 11
- Adaptive resonance theory, 11, 14, 49, 57, 143
- airport scanner, 91, 95
- alternatives to backpropagation, 116
- amount of data, 101
- applications
  - airport scanner texture recognition, 91
  - Boston housing, 74
  - cardiopulmonary modeling, 75
  - Computer Aided Tracking and Characterization of Homicides, 95
  - electronic nose, 89
  - tree classifier, 85
- ART network, 49, 57, 91, 150
- associative memory, 62
- augmented data, 40–41
- axon, 2, 149
  
- backpropagation, 75, 114, 116–117, 119–121, 123, 146
  - advantages, 116
  - alternatives, 116
  - disadvantages, 116
  - process, 113
  - training procedure, 114
- backpropagation of error, 11, 113, 143
- BAM, *see* bidirectional associative memory
- Bayes optimal discriminant, 36
- bias, 2, 4, 15–16, 94, 102–103, 105, 107–108, 113, 138, 144, 146, 149, 159
- biased, 2, 22–24, 45–46
- biased data set, 23
- bidirectional associative memory, 64–65
- biological systems, 1, 143
- bootstrap resampling, 103
- bootstrapping, 103–105
- brain, 1, 143, 147, 149
- Broyden–Fletcher–Goldfarb–Shanno (BFGS) formula, 120
  
- cascade correlation, 117–118
- CATCH, *see* Computer Aided Tracking and Characterization of Homicides
- cell membrane, 2
- city-block distance, *see* taxicab distance
- class membership, 33
- classifier, 19–21, 36, 38–39, 42, 80–81, 85, 125, 128, 144, 146
- clusterer, 21, 144
- clusters, 50, 96, 144
- complexity, 10, 63, 119–120
- components analysis, 27
- Computer Aided Tracking and Characterization of Homicides, 94–95, 156
- confusion matrix, 41, 87, 144
- conjugate gradient, 117
- conjugate gradient descent, 117
- cost function, 63
- credit assignment, 9, 10
- cross-validation, 144
- curse of dimensionality, 26
  
- data collection, 21–24, 77, 90
- data collection plan, 21, 23
- data driven computing, *ix*
- data normalization, 15, 86
- Davidon–Fletcher–Powell (DFP) algorithm, 120
- dendrite, 2, 149
- distance metric, 28–29
  
- eigenvector, 17
- electronic nose, 89–90, 92
- Elman network, 78–79
- energy minimization, 12
- energy normalization, 17
- error surface, 115, 117, 119–120
  - quadratic, 119
- estimation, 74–75, 121
  - estimator, 74, 145
    - function approximation, 71, 73–75, 80
- estimator, 21–22, 34, 74–76, 146
- Euclidean distance, 28–29

- Euclidean norm, 17, 137
- evolutionary computation, 35, 117, 122–123, 145
- feature, 15–17, 22, 24, 26–29, 37, 39, 51–54, 57–58, 80–81, 83, 86, 88, 118, 121, 125–129, 131, 137, 139, 157, 159
  - extraction, 26–27, 86, 159
  - extractor, 27
  - reduction, 26–27
  - redundancy, 27
  - saliency, 125
  - selection, 26
  - space, 24, 28, 39, 54, 80–81, 83, 128
  - vector, 15, 17, 28–29, 38–39, 51–54, 57–58, 81, 88, 131, 137, 139
- feedforward neural network, 8, 20, 35–37, 39, 42–43, 72–73, 75, 81, 83, 92, 107–108, 121, 125, 146–147, 159–160
- firing rate, 2–3, 143
- first-order partial derivatives, 121
- Fisher iris data, 18, 54
- Fisher mapping, 27
- function approximation, *see* estimation
- function approximator, 145
- fuzzy ARTmap, 91
- FuzzyART, 57
- generalization, 44, 46
- Generalized Delta Rule, 110
- genetic algorithms, 122
- gradient descent, 3, 10, 36, 46, 110, 113, 117–122
- Hamming distance, 29
- handwriting recognizer, 84
- hard-limiter, 3
- heavy ball, *see* momentum
- Hebb, 11, 145, 155
- Hessian matrix, 120–122
- hetero-associative networks, 65
- hidden layer, 9, 36–37, 43, 69, 75–76, 78, 91, 107, 109, 112, 114, 123, 126, 145–147
- hidden neuron, 118
- hidden number of neurons, 46
- Hopfield network, 61–66, 68, 132, 134
- hyperbolic tangent function, 31
- hyperplane, 8, 137
- independent-components analysis, 27
- interpolation, 16, 72
- Jackknife Resampling, 102, 146
- Jacobian matrix, 121
- learning rates, 123
- Levenberg–Marquardt, 119, 121–122, 146
- Levenberg–Marquardt training procedure, 122
- linear classifiers, 9
- linear function, 108, 146
- LM algorithm, 121
- LM, *see* Levenberg–Marquardt
- local maxima, 115
- local minima, 115
- logistic function, 31
- logistic sigmoid function, 4, 16, 149
- machine learning, 36, 44–45, 151
- magnetic resonance image, 98–99
- Mahalanobis distance, 29
- Mahalanobis distance metric, 29
- Manhattan distance, *see* taxicab distance
- mapping, 26
- matrix associative memories, 11
- max-picker, 38
- median window filter, 99
- millimeter wave scanner, 92
- min-max normalization, 17
- Minkowski norm, 17
- modular neural network, 40
- momentum, 115, 117, 123
  - heavy ball, 115
- monotonic, 10
- Moore–Penrose, 66, 67
- multiclass neural network, 41
- neighborhood, 49, 51–52, 74, 76–77, 98, 139–140
- nervous system, 1, 11, 148
- net stimulus, 107
- Netlab, 37, 159
- neurons, 1–2
  - hidden, 47
- Newton descent, 119
- nonparametric regression models, 11
- NP-complete, 63
- number of hidden layers, 10
- number of hidden neurons, 43, 45–46, 75, 101
- optical character recognition, 84
- optimization, 120, 122–123
- optimization problems, 63
- outer product, 61, 65
- outer product learning rule, 61, 64
- output coding, 31
- over fit, 46
- overdetermined, 66, 133

- pattern recognition, 17, 19, 24, 53, 71, 80, 84, 86, 88, 91, 150, 152–154
- PCNN, *see* pulse-coupled neural network
- perception, 138, 160
- perceptron, 3, 8–9, 36, 111, 137, 147, 157
- post-processing, 31, 94
- principal components analysis, 17, 27
- principal curves, 27
- pulse-coupled neural network, 96, 148
  
- quasi-Newton, 119–121
- quick propagation, 119, 148
  
- recurrent layer, 78
- recurrent neural networks, 61
- regression, 11
- reinforcement, 9, 11
- relationship, 26
- Repository for Machine Learning databases, 74
- rules of thumb, 42, 46
  
- second order, 121
- second order derivative, 117, 121
- second order gradient, 118–119
- second order gradient techniques, 118
- segmentation, 98
- self-organize, 11, 23, 27
- self-organizer, 21, 23, 27
- self-organizing map, 27, 50, 94–96
- self-organizing system, 22, 154
- sigmoid function, 3, 108, 114
- softmax normalization, 16–17
- spatial data, 22
- split-sample testing, 44–45, 75
- statistical normalization, 17
  
- step function, 33, 62
- stop training, 46
- storage capacity, 62
- supervised approaches, 25
- supervised learning, 13, 35, 46, 74, 147, 150
- synaptic weights, 63, 107, 114
- system identification, 73–74, 80
  
- taxicab distance, 28
- temporal dynamics, *see* time series
- thresholding, 33
- time series, 69, 78
- time series data, 22, 104
- training procedure, 123
- training set, 46
- training time, 15, 32, 36, 75
- transfer function, 3–5, 9, 37, 43, 108, 126, 138, 146–147
- tree classifier, 31, 84
  
- underdetermined, 67, 133
- unit hypersphere, 58
- unsupervised approaches, 25
- unsupervised learning, 13–14, 49, 57, 149, 160
- unsupervised training model, 14, 49
  
- validation error, 46
- validation set, 46
- VC dimension, 43
- visual cortex, 97
  
- weight update, 51–52, 108, 113–115, 119–120, 122, 137, 139
- weights, 114
  
- Z-score normalization, 15, 75, 84, 89, 91, 95

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