References

[1] D. Angluin. On the complexity of minimum inference of regular sets. *Information and Control*, 15(3):237–269, September 1978.

[2] D. Angluin. Learning regular sets from queries and counterexamples. *Information and Computation*, 75:87–106, November 1987.

[3] J. R. Bachrach. Learning to represent state. Master's thesis, University of Massachusetts, Amherst, COINS Department, Amherst, MA 01003, 1988.

[4] J. R. Bachrach. Learning to represent state. In *ICNN Conference Proceedings*, page 288. International Neural Network Society, Pergamon Press, September 1988.

[5] J. R. Bachrach and M. Mozer. Connectionist modeling and controlling of finite state systems in the absence of complete state information. In Yves Chauvin and David E. Rumelhart, editors, *Back-propagation: Theory, Architectures and Applications*. Erlbaum, Hillsdale, NJ, to appear.

[6] A. G. Barto. Connectionist learning for control: An overview. In T. Miller, R. S. Sutton, and P. J. Werbos, editors, *Neural Networks for Control*. The MIT Press, Cambridge, MA, 1990.

[7] A. G. Barto, S. J. Bradtke, and S. P. Singh. real-time learning and control using asynchronous dynamic programming. Technical Report 91-57, University of Massachusetts at Amherst, 1991.

[8] A. G. Barto, R. S. Sutton, and C. W. Anderson. Neuronlike elements that can solve difficult learning control problems. *IEEE Transactions on Systems, Man, and Cybernetics*, 13:835–846, 1983. Reprinted in J. A. Anderson and E. Rosenfeld, *Neurocomputing: Foundations of Research*, The MIT Press, Cambridge, MA, 1988.

[9] A. G. Barto, R. S. Sutton, and C. W. Anderson. Neuronlike adaptive elements that can solve difficult learning control problems. *IEEE Transactions on Systems, Man, and Cybernetics*, SMC-13(15), September/October 1985.

[10] A. G. Barto, R. S. Sutton, and C. Watkins. Learning and sequential decision making. In M. Gabriel and J. W. Moore, editors, *Learning and Computational Neuroscience*. The MIT Press, Cambridge, MA, 1991.

[11] T. L. Booth. *Sequential Machines and Automata Theory*. John Wiley and Sons, Inc., 1967.

[12] J. Bridle. Training stochastic model recognition algorithms as networks can lead to maximum mutual information estimation of parameters. In David S. Touretzky, editor, *Advances in Neural Information Processing Systems 2*, San Mateo, CA, 1990. IEEE Conference on Neural Information Processing Systems—Natural and Synthetic, Morgan Kaufmann Publishers.

[13] R. A. Brooks. A robot that walks: emergent behaviors from a carefully evolved network. *Neural Computation*, 1, 1989.

[14] D. Cohn, L. Atlas, R. Ladner, M. El-sharkawi, R. Marks II, M. Aggoune, and D. Park. Training connectionist networks with queries and selective sampling. In David S. Touretzky, editor, *Advances in Neural Information Processing Systems 2*, San Mateo, CA, 1990. Morgan Kaufmann Publishers.

[15] C. I. Connolly, J. B. Burns, and R. Weiss. Path planning using laplace's equation. In *International Conference on Robotics and Automation*, 1990.

[16] R. O. Duda and P. E. Hart. *Pattern Classification and Scene Analysis*. Wiley, New York, 1973.

[17] R. Durbin. Principled competitive learning in both unsupervised and supervised networks. Poster presented at the conference on Neural Networks for Computing, Snowbird, UT, April 1990.

[18] R. Durbin and J. R. Bachrach. Diversity-based representations of stochastic finite state automata. Unpublished Manuscript, 1990.

[19] R. Durbin and D. E. Rumelhart. Product units: A computationally powerful and biologically plausible extension. *Neural Computation*, ?(?), ? 1989.

[20] T. F. Elbert. *Estimation and Control of Systems*. Van Nostrand Reinhold Company, 1984.

[21] J. L. Elman. Finding structure in time. Technical Report 8801, Center for Research in Language: University of California, San Diego, April 1988.

[22] J. L. Elman. Finding structure in time. *Cognitive Science*, 14:179–212, 1990.

[23] C. Fennema, A. Hanson, and E. Riseman. Towards autonomous mobile robot navigation. Technical Report 89-104, Computer Science Department, University of Massachusetts, 1989.

[24] B. R. Gaines. Behavior/structure transformations under uncertainty. *International Journal of Man-Machine Studies*, 8:337–365, 1976.

[25] A. Gelb. *Optimal Estimation*. MIT Press, 1974.

[26] C. L. Giles, G. Z. Sun, H. H. Chen, Y. C. Lee, and D. Chen. Higher order recurrent networks and grammatical inference. In David S. Touretzky, editor, *Advances in Neural Information Processing Systems 2*, San Mateo, CA, 1990. IEEE Conference on Neural Information Processing Systems—Natural and Synthetic, Morgan Kaufmann Publishers.

[27] A. Gill. *Introduction to the theory of finite-state machines.* McGraw-Hill, 1962.

[28] E. M. Gold. System identification via state characterization. *Automatica*, 8:621–636, 1972.

[29] E. M. Gold. Complexity of automaton identification from given data,. *Information and Control*, 37, 1978.

[30] G. C. Goodwin and K. S. Sin. *Adaptive Filtering Prediction and Control.* Prentice Hall, 1984.

[31] G. E. Hinton. Connectionist learning procedures. Technical Report CMU-CS-87-115, Department of Computer Science, Carnegie-Mellon University, Pittsburgh, PA 15213, 1987.

[32] K. Hornik, M. Stinchcombe, and H. White. Multi-layer feedforward networks are universal approximators. Technical report, Department of Economics, University of California, San Diego, CA, June 1988.

[33] R. Jacobs. *Task decomposition through competition in a modular connectionist architecture.* PhD thesis, COINS Department, University of Massachusetts, Amherst, MA 01003, 1990.

[34] M. I. Jordan. *The learning of representations for sequential Performance.* PhD thesis, University of California, San Diego, 1985.

[35] M. I. Jordan. Indeterminate motor skill learning problems. In M. Jearnnerod, editor, *Attention and Performance*, volume XIII. MIT Press, 1990.

[36] M. I. Jordan and R. Jacobs. Learning to control an unstable system with forward modeling. In David S. Touretzky, editor, *Advances in Neural Information Processing Systems*, P.O. Box 50490, Palo Alto, CA 94303, 1989. Morgan Kaufmann Publishers.

[37] Michael I. Jordan and David E. Rumelhart. Supervised learning with a distal teacher. *Cognitive Science*, 1990. Submitted.

[38] L. Kaelbling. *Learning in Embedded Systems.* PhD thesis, Stanford University, 1990.

[39] M. Kearns and L. G. Valiant. Learning boolean formulae or finite automata is as hard as factoring. Technical Report TR 14-88, Harvard Univsity Aiken Computation Laboratory, 1988.

[40] O. Khatib. Real-time obstacle avoidance for manipulators and mobile robots. In *International Conference on Robotics and Automation*, pages 500–505. IEEE, March 1985.

[41] G. J. Klir. On the representation of activity arrays. *International Journal of General Systems*, 2:149–168, 1975.

[42] G. J. Klir. Identification of generative structures in empirical data. *International Journal of General Systems*, 3:89–104, 1976.

[43] D. E. Koditschek. Exact robot navigation by means of potential functions: some topological considerations. In *International Conference on Robotics and Automation*, pages 1–6. IEEE, April 1987.

[44] Z. Kohavi. *Switching and finite automata theory.* McGraw-Hill, 1978.

[45] B. H. Krogh. A generalized potential field approach to obstacle avoidance control. In *Robotics Research: The Next Five Years and Beyond.* Society of Manufacturing Engineers, August 1984.

[46] J. E. Laird, A. Newell, and P. S. Rosenbloom. SOAR: An architecture for general intelligence. *Artificial Intelligence*, 33:1–64, 1987.

[47] J. Latombe. *Robot Motion Planning.* Kluwer Academic Press, 1990.

[48] Y. le Cun. Une procedure d'apprentissage pour reseau a sequil assymetrique [A learning procedure for asymmetric threshold network]. *Proceedings of Cognitiva*, 85:599–604, 1985.

[49] L. Ljung and T. Soderstrom. *Theory and Practice of Recursive Identification.* MIT Press, 1982.

[50] P. Maes and R. Brooks. Learning to coordinate behaviours. In *Proceedings of the eighth AAAI*, pages 796–802. Morgan Kaufmann, 1990.

[51] S. Mahadevan and J. Connell. Automatic programming of behavior-based robots using reinforcemnt learning. Technical report, IBM Research Division, T.J. Watson Research Center, Box 704, Yorktown Heights, NY 10598, 1990.

[52] M. J. Mataric. Environment learning using a distributed representation. In *1990 IEEE International Conference on Robotics and Automation*, Los Alamitos, CA, 1990. IEEE Computer Society Press.

[53] J. L. McClelland and J. L. Elman. *Interactive Processes in Speech Perception: The TRACE Model*, pages 58–121. MIT Press, 1986.

[54] J. L. McClelland and D. E. Rumelhart. An interactive activation model of context effects in letter perception: Part 1. an account of basic findings. *Psychological Review*, 88:375–407, 1981.

[55] M. C. Mozer. A focused back-propagation algorithm for temporal pattern recognition. Technical Report ?, Department of Psychology and Computer Science University of Toronto, Toronto, Ontario M5S1A1, CANADA, ? 1988.

[56] M. C. Mozer. A focused back-propagation algorithm for temporal pattern recognition. *complex systems*, 3(4):349–381, 1989.

[57] M. C. Mozer and J. R. Bachrach. Discovering the structure of a reactive environment by exploration. Technical Report CU-CS-451-89, University of Colorado at Boulder Department of Computer Science, November 1989.

[58] M. C. Mozer and J. R. Bachrach. Discovering the structure of a reactive environment by exploration. In David S. Touretzky, editor, *Advances in Neural Information Processing Systems 2*, San Mateo, CA, 1990. IEEE Conference on Neural Information Processing Systems—Natural and Synthetic, Morgan Kaufmann Publishers.

[59] M. C. Mozer and J. R. Bachrach. Discovering the structure of a reactive environment by exploration. *Neural Computation*, 2(4), 1990.

[60] M. C. Mozer and J. R. Bachrach. Discovering the structure of a reactive environment by exploration. *Machine Learning Journal*, 1991.

[61] K. S. Narendra and K. Parthasarathy. Identification and control of dynamical systems using neural networks. *IEEE transactions on neural networks*, 1(1):4–27, 1990.

[62] S. J. Nowlan. Competing experts: an experimental investigation of associative mixture models. Technical Report CRG-TR-90-5, Department of Computer Science, University of Toronto, 1990.

[63] S. J. Nowlan. A generative framework for unsupervised learning. In David S. Touretzky, editor, *Advances in Neural Information Processing Systems 2*, San Mateo, CA, 1990. IEEE Conference on Neural Information Processing Systems—Natural and Synthetic, Morgan Kaufmann Publishers.

[64] J. Park and S. Lee. Neural computation for collision-free path planning. In *Proceedings of the international joint conference on neural networks*, Hillsdale, NJ, 1990. Lawrence Erlbaum. Volume 2: Applications Track.

[65] D. B. Parker. Learning logic. Technical Report TR-47, Massachusetts Institute of Technology, 1985.

[66] B. A. Pearlmutter. Learning state space trajectories in recurrent neural networks. *Neural Computation*, 1(2):263–269, Summer 1989.

[67] L. Pitt and M. K. Warmuth. The minimum DFA consistency problem cannot be approximated within any polynomial. In *Proceedings of the Twenty-First Annual ACM Symposium on Theory of Computing*, Seattle, Washington, May 1989. ACM.

[68] J. B. Pollack. Language acquisition via strange automata. In *Proceedings of the Twelfth Annual Conference of the Cognitive Science Society*, Hillsdale, NJ, 1990. Cognitive Science Society, Erlbaum.

[69] D. A. Pomerleau. Alvinn: an autonomous land vehicle in a neural network. In David S. Touretzky, editor, *Advances in Neural Information Processing Systems 1*, San Mateo, CA, 1989. IEEE Conference on Neural Information Processing Systems—Natural and Synthetic, Morgan Kaufmann Publishers.

[70] S. Porat and J. A. Feldman. Learning automata from ordered examples. Technical Report TR241, University of Rochester, March 1988.

[71] E. Rimon and D. E. Koditschek. Exact robot navigation using cost functions: the case of distinct spherical boundaries in e^n. In *International Conference on Robotics and Automation*, pages 1791–1796. IEEE, April 1988.

[72] R. L. Rivest and R. E. Schapire. Diversity-based inference of finite automata. In *Proceedings of the Twenty-Eighth Annual Symposium on Foundations of Computer Science*, pages 78–87, 1987.

[73] R. L. Rivest and R. E. Schapire. Diversity-based inference of finite automata. Technical report, Massachusetts Institute of Technology, 1987.

[74] R. L. Rivest and R. E. Schapire. A new approach to unsupervised learning in deterministic environments. In Pat Langley, editor, *Proceedings of the Fourth International Workshop on Machine Learning*, pages 364–375, 1987.

[75] R. L. Rivest and R. E. Schapire. Inference of finite automata using homing sequences. In *Proceedings of the Twenty-First Annual ACM Symposium on Theory of Computing*, May 1989.

[76] A. J. Robinson and F. Fallside. The utility driven dynamic error propagation network. Technical Report CUED/F-INFENG/TR.1, Cambridge University Engineering Department, Cambridge, England, 1987.

[77] D. E. Rumelhart. Personal communication.

[78] D. E. Rumelhart. Specialized architectures for back propagation learning. Paper presented at the conference on Neural Networks for Computing, Snowbird, UT., April 1989.

[79] D. E. Rumelhart, G. E. Hinton, and R. J. Williams. Learning internal representations by error propagation. In D. E. Rumelhart and J. L. McClelland, editors, *Parallel Distributed Processing: Explorations in the Microstructure of Cognition, vol.1: Foundations*. Bradford Books/MIT Press, Cambridge, MA, 1986.

[80] D. E. Rumelhart and J. L. McClelland. An interactive activation model of context effects in letter perception: Part 2. the contextual enhancement effect and some tests and extensions of the model. *Psychological Review*, 89:60–94, 1982.

[81] D. E. Rumelhart and J. L. McClelland. On learning the past tenses of verbs. In D. E. Rumelhart, J. L. McClelland, and the PDP research group, editors, *Parallel Distributed Processing: Psychological and biological models*, chapter 18, pages 216–272. MIT press, 1986.

[82] E. D. Sacerdoti. Planning in a hierarchy of abstraction spaces. *Artificial Intelligence*, 5:115–135, 1974.

[83] A. L. Samuel. Some studies in machine learning using the game of checkers. *IBM Journal on Research and Development*, pages 210–229, 1959. Reprinted in E. A. Feigenbaum and J. Feldman, editors, *Computers and Thought*, McGraw-Hill, New York, 1963.

[84] R. E. Schapire. Personal communication.

[85] R. E. Schapire. Diversity-based inference of finite automata. Master's thesis, MIT, 1988.

[86] J. H. Schmidhuber. Towards compositional learning with dynamic neural networks. Technical Report FKI-129-90, Technische Universitat Munchen, 1990.

[87] T. J. Sejnowski and C. R. Rosenberg. NETtalk: A parallel network that learns to talk. Technical Report EECS-8601, Johns Hopkins University, Department of Electrical and Computer Engineering, Baltimore, MD, 1986.

[88] D. Servan-Schreiber, A. Cleeremans, and J. L. McClelland. Learning sequential structure in simple recurrent networks. In David S. Touretzky, editor, *Advances in Neural Information Processing Systems 1*, San Mateo, CA, 1989. IEEE Conference on Neural Information Processing Systems—Natural and Synthetic, Morgan Kaufmann Publishers.

[89] D. Servan-Schreiber, A. Cleermans, and J. L. McClelland. Encoding sequential structure in simple recurrent networks. Technical Report CMU-CS-88-183, Carnegie-Mellon University, Department of Computer Science, Pittsburgh, PA, 1988.

[90] S. P. Singh. Transfer of learning by composing solutions for elemental sequential tasks. In *Proceedings of the Machine Learning Workshop*, 1991.

[91] W. S. Stornetta and B. A. Huberman. An improved three-layer back propagation algorithm. In *Proceedings of the IEEE First Annual International Conference on Neural Networks*, pages 637–643, 1987.

[92] R. S. Sutton. *Temporal Credit Assignment in Reinforcement Learning.* PhD thesis, Department of Computer and Information Science, University of Massachusetts at Amherst, 1984.

[93] R. S. Sutton. Learning to predict by the methods of temporal differences. *Machine Learning*, 3:9–44, 1988.

[94] R. S. Sutton. Integrated architectures for learning, planning, and reacting based on approximating dynamic programming. In *Proceedings of the Seventh International Conference on Machine Learning*, pages 216–224, San Mateo, CA, 1990. Morgan Kaufmann.

[95] R. S. Sutton and B. Pinette. The learning of world models by connectionist networks. In *Proceedings of the Seventh Annual Conference of the Cognitive Science Society*, Irvine, CA, 1985.

[96] A. Waibel, T. Hanazawa, G. Hinton, K. Shikano, and K. Lang. Phoneme recognition using time-delay neural networks. Technical report, ATR Interpreting Telephony Research Laboratories, 1987.

[97] C. J. C. H. Watkins. *Learning from Delayed Rewards.* PhD thesis, Cambridge University, Cambridge, England, 1989. Pending.

[98] R. L. Watrous and L. Shastri. Learning phonetic features using connectionist networks: An experiment in speech recognition. Technical report, Department of Computer and Information Science; Moore School; University of Pennsylvania, 1986.

[99] P. J. Werbos. *Beyond Regression: New Tools for Prediction and Analysis in the Behavioral Sciences.* PhD thesis, Harvard University, 1974.

[100] P. J. Werbos. Building and understanding adaptive systems: A statistical/numerical approach to factory automation and brain research. *IEEE Transactions on Systems, Man, and Cybernetics*, 1987.

[101] P. J. Werbos. Reinforcement learning over time. In T. Miller, R. S. Sutton, and P. J. Werbos, editors, *Neural Networks for Control.* The MIT Press, Cambridge, MA, 1990.

[102] S. D. Whitehead and D. H. Ballard. Active perception and reinforcement learning. In *Proceedings of the seventh international conference on machine learning*, Austin, TX, June 1990.

[103] B. Widrow and S. D. Stearns. *Adaptive Signal Processing.* Prentice Hall, 1985.

[104] R. J. Williams and D. Zipser. A learning algorithm for continually running fully recurrent neural networks. Technical Report 8805, Institute for Cognitive Science, C-015; University of California, San Diego; La Jolla, CA 92093, 1988.

[105] R. J. Williams and D. Zipser. A learning algorithm for continually running fully recurrent neural networks. *Neural Computation*, 1(2):270–280, 1989.

[106] R. J. Williams and D. Zipser. Gradient-based learning algorithms for recurrent connectionist networks. In Y. Chauvin and D. E. Rumelhart, editors, *Backpropagation: Theory, Architectures and Applications*. Erlbaum, Hillsdale, NJ, to appear.

[107] I. H. Witten. Approximate, non-deterministic modeling of behavior sequences. *International Journal of General Systems*, 5(1):1–12, Jan 1979.