- [Lev92] J. L. Leva. A normal random number generator. ACM Trans. Math. Softw., 18(4):454–455, December 1992.
- [Lew82] J. G. Lewis. The Gibbs-Poole-Stockmeyer and Gibbs-King algorithms for reordering sparse matrices. ACM Trans. Math. Softw., 8(2):190–194, June 1982.
- [LL96] A. LaMarca and R. Ladner. The influence of caches on the performance of heaps. ACM J. Experimental Algorithmics, 1, 1996.
- [LL99] A. LaMarca and R. Ladner. The influence of caches on the performance of sorting. J. Algorithms, 31:66–104, 1999.
- [LLK83] J. K. Lenstra, E. L. Lawler, and A. Rinnooy Kan. Theory of Sequencing and Scheduling. Wiley, New York, 1983.
- [LLKS85] E. Lawler, J. Lenstra, A. Rinnooy Kan, and D. Shmoys. The Traveling Salesman Problem. John Wiley, 1985.
- [LLS92] L. Lam, S.-W. Lee, and C. Suen. Thinning methodologies a comprehensive survey. IEEE Trans. Pattern Analysis and Machine Intelligence, 14:869–885, 1992.
- [LM04] M. Lin and D. Manocha. Collision and proximity queries. In J. Goodman and J. O'Rourke, editors, *Handbook of Discrete and Computational Geom*etry, pages 787–807. CRC Press, 2004.
- [LMM02] A. Lodi, S. Martello, and M. Monaci. Two-dimensional packing problems: A survey. European J. Operations Research, 141:241-252, 2002.
- [LMS06] L. Lloyd, A. Mehler, and S. Skiena. Identifying co-referential names across large corpora. In *Combinatorial Pattern Matching (CPM 2006)*, pages 12–23. Lecture Notes in Computer Science, v.4009, 2006.
- [LP86] L. Lovász and M. Plummer. Matching Theory. North-Holland, Amsterdam, 1986.
- [LP02] W. Langdon and R. Poli. Foundations of Genetic Programming. Springer, 2002.
- [LP07] A. Lodi and A. Punnen. TSP software. In G. Gutin and A. Punnen, editors, The Traveling Salesman Problem and Its Variations, pages 737–749. Springer, 2007.
- [LPW79] T. Lozano-Perez and M. Wesley. An algorithm for planning collision-free paths among polygonal obstacles. Comm. ACM, 22:560-570, 1979.
- [LR93] K. Lang and S. Rao. Finding near-optimal cuts: An empirical evaluation. In Proc. 4th Annual ACM-SIAM Symposium on Discrete Algorithms (SODA '93), pages 212–221, 1993.
- [LS87] V. Lumelski and A. Stepanov. Path planning strategies for a point mobile automaton moving amidst unknown obstacles of arbitrary shape. Algorithmica, 3:403-430, 1987.
- [LS95] Y.-L. Lin and S. Skiena. Algorithms for square roots of graphs. SIAM J. Discrete Mathematics, 8:99–118, 1995.

- [LSCK02] P. L'Ecuyer, R. Simard, E. Chen, and W. D. Kelton. An object-oriented random-number package with many long streams and substreams. Operations Research, 50:1073–1075, 2002.
- [LT79] R. Lipton and R. Tarjan. A separator theorem for planar graphs. SIAM Journal on Applied Mathematics, 36:346–358, 1979.
- [LT80] R. Lipton and R. Tarjan. Applications of a planar separator theorem. SIAM J. Computing, 9:615–626, 1980.
- [Luc91] E. Lucas. Récréations Mathématiques. Gauthier-Villares, Paris, 1891.
- [Luk80] E. M. Luks. Isomorphism of bounded valence can be tested in polynomial time. In *Proc. of the 21st Annual Symposium on Foundations of Computing*, pages 42–49. IEEE, 1980.
- [LV88] G. Landau and U. Vishkin. Fast string matching with k differences. J. Comput. System Sci., 37:63–78, 1988.
- [LV97] M. Li and P. Vitányi. An introduction to Kolmogorov complexity and its applications. Springer-Verlag, New York, second edition, 1997.
- [LW77] D. T. Lee and C. K. Wong. Worst-case analysis for region and partial region searches in multidimensional binary search trees and balanced quad trees. Acta Informatica, 9:23–29, 1977.
- [LW88] T. Lengauer and E. Wanke. Efficient solution of connectivity problems on hierarchically defined graphs. SIAM J. Computing, 17:1063-1080, 1988.
- [Mah76] S. Maheshwari. Traversal marker placement problems are NP-complete. Technical Report CU-CS-09276, Department of Computer Science, University of Colorado, Boulder, 1976.
- [Mai78] D. Maier. The complexity of some problems on subsequences and supersequences. J. ACM, 25:322–336, 1978.
- [Mak02] R. Mak. Java Number Cruncher: The Java Programmer's Guide to Numerical Computing. Prentice Hall, 2002.
- [Man89] U. Manber. Introduction to Algorithms. Addison-Wesley, Reading MA, 1989.
- [Mar83] S. Martello. An enumerative algorithm for finding Hamiltonian circuits in a directed graph. ACM Trans. Math. Softw., 9(1):131–138, March 1983.
- [Mat87] D. W. Matula. Determining edge connectivity in O(nm). In 28th Ann. Symp. Foundations of Computer Science, pages 249–251. IEEE, 1987.
- [McC76] E. McCreight. A space-economical suffix tree construction algorithm. J. ACM, 23:262–272, 1976.
- [McK81] B. McKay. Practical graph isomorphism. Congressus Numerantium, 30:45–87, 1981.
- [McN83] J. M. McNamee. A sparse matrix package part II: Special cases. *ACM Trans. Math. Softw.*, 9(3):344–345, September 1983.
- [MDS01] D. Musser, G. Derge, and A. Saini. STL Tutorial and Reference Guide: C++ Programming with the Standard Template Library. Addison-Wesley Professional, second edition, 2001.

- [Meg83] N. Megiddo. Linear time algorithm for linear programming in r^3 and related problems. SIAM J. Computing, 12:759–776, 1983.
- [Men27] K. Menger. Zur allgemeinen Kurventheorie. Fund. Math., 10:96–115, 1927.
- [Mey01] S. Meyers. Effective STL: 50 Specific Ways to Improve Your Use of the Standard Template Library. Addison-Wesley Professional, 2001.
- [MF00] Z. Michalewicz and D. Fogel. How to Solve it: Modern Heuristics. Springer, Berlin, 2000.
- [MG92] J. Misra and D. Gries. A constructive proof of Vizing's theorem. Info. Processing Letters, 41:131–133, 1992.
- [MG06] J. Matousek and B. Gartner. Understanding and Using Linear Programming. Springer, 2006.
- [MGH81] J. J. Moré, B. S. Garbow, and K. E. Hillstrom. Fortran subroutines for testing unconstrained optimization software. ACM Trans. Math. Softw., 7(1):136–140, March 1981.
- [MH78] R. Merkle and M. Hellman. Hiding and signatures in trapdoor knapsacks. IEEE Trans. Information Theory, 24:525–530, 1978.
- [Mie58] W. Miehle. Link-minimization in networks. Operations Research, 6:232–243, 1958.
- [Mil76] G. Miller. Riemann's hypothesis and tests for primality. J. Computer and System Sciences, 13:300–317, 1976.
- [Mil97] V. Milenkovic. Multiple translational containment. part II: exact algorithms. $Algorithmica,\ 19:183-218,\ 1997.$
- [Min78] H. Minc. Permanents, volume 6 of Encyclopedia of Mathematics and its Applications. Addison-Wesley, Reading MA, 1978.
- [Mit99] J. Mitchell. Guillotine subdivisions approximate polygonal subdivisions: A simple polynomial-time approximation scheme for geometric TSP, k-mst, and related problems. SIAM J. Computing, 28:1298–1309, 1999.
- [MKT07] E. Mardis, S. Kim, and H. Tang, editors. Advances in Genome Sequencing Technology and Algorithms. Artech House Publishers, 2007.
- [MM93] U. Manber and G. Myers. Suffix arrays: A new method for on-line string searches. SIAM J. Computing, pages 935–948, 1993.
- [MM96] K. Mehlhorn and P. Mutzel. On the embedding phase of the Hopcroft and Tarjan planarity testing algorithm. *Algorithmica*, 16:233–242, 1996.
- [MMI72] D. Matula, G. Marble, and J. Isaacson. Graph coloring algorithms. In R. C. Read, editor, Graph Theory and Computing, pages 109–122. Academic Press, 1972.
- [MMZ⁺01] M. Moskewicz, C. Madigan, Y. Zhao, L. Zhang, and S. Malik. Chaff: Engineering an efficient SAT solver. In 39th Design Automation Conference (DAC), 2001.
- [MN98] M. Matsumoto and T. Nishimura. Mersenne twister: A 623-dimensionally equidistributed uniform pseudorandom number generator. ACM Trans. on Modeling and Computer Simulation, 8:3–30, 1998.

- [MN99] K. Mehlhorn and S. Naher. LEDA: A platform for combinatorial and geometric computing. Cambridge University Press, 1999.
- [MN07] V. Makinen and G. Navarro. Compressed full text indexes. ACM Computing Surveys, 39, 2007.
- [MO63] L. E. Moses and R. V. Oakford. Tables of Random Permutations. Stanford University Press, Stanford, Calif., 1963.
- [Moe90] S. Moen. Drawing dynamic trees. *IEEE Software*, 7-4:21–28, 1990.
- [Moo59] E. F. Moore. The shortest path in a maze. In *Proc. International Symp. Switching Theory*, pages 285–292. Harvard University Press, 1959.
- [MOS06] K. Mehlhorn, R. Osbild, and M. Sagraloff. Reliable and efficient computational geometry via controlled perturbation. In *Proc. Int. Coll. on Automata, Languages, and Programming (ICALP)*, volume 4051, pages 299–310. Springer Verlag, Lecture Notes in Computer Science, 2006.
- [Mou04] D. Mount. Geometric intersection. In J. Goodman and J. O'Rourke, editors, Handbook of Discrete and Computational Geometry, pages 857–876. CRC Press, 2004.
- [MOV96] A. Menezes, P. Oorschot, and S. Vanstone. Handbook of Applied Cryptography. CRC Press, Boca Raton, 1996.
- [MP80] W. Masek and M. Paterson. A faster algorithm for computing string edit distances. J. Computer and System Sciences, 20:18–31, 1980.
- [MPC⁺06] S. Mueller, D. Papamichial, J.R. Coleman, S. Skiena, and E. Wimmer. Reduction of the rate of poliovirus protein synthesis through large scale codon deoptimization causes virus attenuation of viral virulence by lowering specific infectivity. J. of Virology, 80:9687–96, 2006.
- [MPT99] S. Martello, D. Pisinger, and P. Toth. Dynamic programming and strong bounds for the 0-1 knapsack problem. *Management Science*, 45:414–424, 1999.
- [MPT00] S. Martello, D. Pisinger, and P. Toth. New trends in exact algorithms for the 0-1 knapsack problem. European Journal of Operational Research, 123:325– 332, 2000.
- [MR95] R. Motwani and P. Raghavan. Randomized Algorithms. Cambridge University Press, New York, 1995.
- [MR01] W. Myrvold and F. Ruskey. Ranking and unranking permutations in linear time. Info. Processing Letters, 79:281–284, 2001.
- [MR06] W. Mulzer and G. Rote. Minimum weight triangulation is NP-hard. In *Proc.* 22nd ACM Symp. on Computational Geometry, pages 1–10, 2006.
- [MRRT53] N. Metropolis, A. W. Rosenbluth, M. N. Rosenbluth, and A. H. Teller. Equation of state calculations by fast computing machines. *Journal of Chemical Physics*, 21(6):1087–1092, June 1953.
- [MS91] B. Moret and H. Shapiro. Algorithm from P to NP: Design and Efficiency. Benjamin/Cummings, Redwood City, CA, 1991.

- [MS93] M. Murphy and S. Skiena. Ranger: A tool for nearest neighbor search in high dimensions. In Proc. Ninth ACM Symposium on Computational Geometry, pages 403–404, 1993.
- [MS95a] D. Margaritis and S. Skiena. Reconstructing strings from substrings in rounds. Proc. 36th IEEE Symp. Foundations of Computer Science (FOCS), 1995.
- [MS95b] J. S. B. Mitchell and S. Suri. Separation and approximation of polyhedral objects. Comput. Geom. Theory Appl., 5:95–114, 1995.
- [MS00] M. Mascagni and A. Srinivasan. Algorithm 806: Sprng: A scalable library for pseudorandom number generation. ACM Trans. Mathematical Software, 26:436–461, 2000.
- [MS05] D. Mehta and S. Sahni. Handbook of Data Structures and Applications. Chapman and Hall / CRC, Boca Raton, FL, 2005.
- [MT85] S. Martello and P. Toth. A program for the 0-1 multiple knapsack problem. ACM Trans. Math. Softw., 11(2):135–140, June 1985.
- [MT87] S. Martello and P. Toth. Algorithms for knapsack problems. In S. Martello, editor, Surveys in Combinatorial Optimization, volume 31 of Annals of Discrete Mathematics, pages 213–258. North-Holland, 1987.
- [MT90a] S. Martello and P. Toth. Knapsack problems: algorithms and computer implementations. Wiley, New York, 1990.
- [MT90b] K. Mehlhorn and A. Tsakalidis. Data structures. In J. van Leeuwen, editor, Handbook of Theoretical Computer Science: Algorithms and Complexity, volume A, pages 301–341. MIT Press, 1990.
- [MU05] M. Mitzenmacher and E. Upfal. robability and Computing: Randomized Algorithms and Probabilistic Analysis. Cambridge University Press, 2005.
- [Mul94] K. Mulmuley. Computational Geometry: an introduction through randomized algorithms. Prentice-Hall, New York, 1994.
- [Mut05] S. Muthukrishnan. Data Streams: Algorithms and Applications. Now Publishers, 2005.
- [MV80] S. Micali and V. Vazirani. An $o(\sqrt{|V|}|e|)$ algorithm for finding maximum matchings in general graphs. In *Proc. 21st. Symp. Foundations of Computing*, pages 17–27, 1980.
- [MV99] B. McCullough and H. Vinod. The numerical reliability of econometical software. J. Economic Literature, 37:633-665, 1999.
- [MY07] K. Mehlhorn and C. Yap. Robust Geometric Computation. manuscript, http://cs.nyu.edu/yap/book/egc/, 2007.
- [Mye86] E. Myers. An O(nd) difference algorithm and its variations. Algorithmica, 1:514–534, 1986.
- [Mye99a] E. Myers. Whole-genome DNA sequencing. IEEE Computational Engineering and Science, 3:33–43, 1999.
- [Mye99b] G. Myers. A fast bit-vector algorithm for approximate string matching based on dynamic programming. J. ACM, 46:395–415, 1999.

- [Nav01a] G. Navarro. A guided tour to approximate string matching. ACM Computing Surveys, 33:31–88, 2001.
- [Nav01b] G. Navarro. Nr-grep: a fast and flexible pattern matching tool. Software Practice and Experience, 31:1265–1312, 2001.
- [Nel96] M. Nelson. Fast searching with suffix trees. Dr. Dobbs Journal, August 1996.
- [Neu63] J. Von Neumann. Various techniques used in connection with random digits. In A. H. Traub, editor, John von Neumann, Collected Works, volume 5. Macmillan, 1963.
- [NI92] H. Nagamouchi and T. Ibaraki. Computing edge-connectivity in multigraphs and capacitated graphs. SIAM J. Disc. Math, 5:54-55, 1992.
- [NMB05] W. Nooy, A. Mrvar, and V. Batagelj. Exploratory Social Network Analysis with Pajek. Cambridge University Press, 2005.
- [NOI94] H. Nagamouchi, T. Ono, and T. Ibaraki. Implementing an efficient minimum capacity cut algorithm. Math. Prog., 67:297–324, 1994.
- [Not02] C. Notredame. Recent progress in multiple sequence alignment: a survey. Pharmacogenomics, 3:131–144, 2002.
- [NR00] G. Navarro and M. Raffinot. Fast and flexible string matching by combining bit-parallelism and suffix automata. ACM J. of Experimental Algorithmics, 5, 2000.
- [NR04] T. Nishizeki and S. Rahman. Planar Graph Drawing. World Scientific, 2004.
- [NR07] G. Navarro and M. Raffinot. Flexible Pattern Matching in Strings: Practical On-Line Search Algorithms for Texts and Biological Sequences. Cambridge University Press, 2007.
- [NS07] G. Narasimhan and M. Smid. Geometric Spanner Networks. Cambridge Univ. Press, 2007.
- [Nuu95] E. Nuutila. Efficient transitive closure computation in large digraphs. http://www.cs.hut.fi/~enu/thesis.html, 1995.
- [NW78] A. Nijenhuis and H. Wilf. Combinatorial Algorithms for Computers and Calculators. Academic Press, Orlando FL, second edition, 1978.
- [NZ80] I. Niven and H. Zuckerman. An Introduction to the Theory of Numbers. Wiley, New York, fourth edition, 1980.
- [NZ02] S. Näher and O. Zlotowski. Design and implementation of efficient data types for static graphs. In European Symposium on Algorithms (ESA), pages 748-759, 2002.
- [OBSC00] A. Okabe, B. Boots, K. Sugihara, and S. Chiu. Spatial Tessellations: Concepts and Applications of Voronoi Diagrams. Wiley, 2000.
- [Ogn93] R. Ogniewicz. Discrete Voronoi Skeletons. Hartung-Gorre Verlag, Konstanz, Germany, 1993.
- [O'R85] J. O'Rourke. Finding minimal enclosing boxes. Int. J. Computer and Information Sciences, 14:183–199, 1985.
- [O'R87] J. O'Rourke. Art Gallery Theorems and Algorithms. Oxford University Press, Oxford, 1987.

- [O'R01] J. O'Rourke. Computational Geometry in C. Cambridge University Press, New York, second edition, 2001.
- [Ort88] J. Ortega. Introduction to Parallel and Vector Solution of Linear Systems. Plenum, New York, 1988.
- [OS04] J. O'Rourke and S. Suri. Polygons. In J. Goodman and J. O'Rourke, editors, Handbook of Discrete and Computational Geometry, pages 583–606. CRC Press, 2004.
- [OvL81] M. Overmars and J. van Leeuwen. Maintenance of configurations in the plane. J. Computer and System Sciences, 23:166–204, 1981.
- [OW85] J. O'Rourke and R. Washington. Curve similarity via signatures. In G. T. Toussaint, editor, Computational Geometry, pages 295–317. North-Holland, Amsterdam, Netherlands, 1985.
- [P57] G. Pólya. How to Solve It. Princeton University Press, Princeton NJ, second edition, 1957.
- [Pan06] R. Panigrahy. Hashing, Searching, Sketching. PhD thesis, Stanford University, 2006.
- [Pap76a] C. Papadimitriou. The complexity of edge traversing. J. ACM, 23:544–554, 1976.
- [Pap76b] C. Papadimitriou. The NP-completeness of the bandwidth minimization problem. Computing, 16:263–270, 1976.
- [Par90] G. Parker. A better phonetic search. C Gazette, 5-4, June/July 1990.
- [Pas97] V. Paschos. A survey of approximately optimal solutions to some covering and packing problems. Computing Surveys, 171-209:171-209, 1997.
- [Pas03] V. Paschos. Polynomial approximation and graph-coloring. Computing, 70:41–86, 2003.
- [Pav82] T. Pavlidis. Algorithms for Graphics and Image Processing. Computer Science Press, Rockville MD, 1982.
- [Pec04] M. Peczarski. New results in minimum-comparison sorting. Algorithmica, 40:133-145, 2004.
- [Pec07] M. Peczarski. The Ford-Johnson algorithm still unbeaten for less than 47 elements. Info. Processing Letters, 101:126–128, 2007.
- [Pet03] J. Petit. Experiments on the minimum linear arrangement problem. ACM J. of Experimental Algorithmics, 8, 2003.
- [PFTV07] W. Press, B. Flannery, S. Teukolsky, and W. T. Vetterling. Numerical Recipes: the art of scientific computing. Cambridge University Press, third edition, 2007.
- [PH80] M. Padberg and S. Hong. On the symmetric traveling salesman problem: a computational study. Math. Programming Studies, 12:78–107, 1980.
- [PIA78] Y. Perl, A. Itai, and H. Avni. Interpolation search a $\log \log n$ search. Comm. ACM, 21:550–554, 1978.
- [Pin02] M. Pinedo. Scheduling: Theory, Algorithms, and Systems. Prentice Hall, second edition, 2002.

- [PL94] P. A. Pevzner and R. J. Lipshutz. Towards DNA sequencing chips. In 19th Int. Conf. Mathematical Foundations of Computer Science, volume 841, pages 143–158, Lecture Notes in Computer Science, 1994.
- [PLM06] F. Panneton, P. L'Ecuyer, and M. Matsumoto. Improved long-period generators based on linear recurrences modulo 2. ACM Trans. Mathematical Software, 32:1–16, 2006.
- [PM88] S. Park and K. Miller. Random number generators: Good ones are hard to find. Communications of the ACM, 31:1192–1201, 1988.
- [PN04] Shortest Paths and Networks. J. Mitchell. In J. Goodman and J. O'Rourke, editors, Handbook of Discrete and Computational Geometry, pages 607–641. CRC Press, 2004.
- [Pom84] C. Pomerance. The quadratic sieve factoring algorithm. In T. Beth, N. Cot, and I. Ingemarrson, editors, Advances in Cryptology, volume 209, pages 169–182. Lecture Notes in Computer Science, Springer-Verlag, 1984.
- [PP06] M. Penner and V. Prasanna. Cache-friendly implementations of transitive closure. ACM J. of Experimental Algorithmics, 11, 2006.
- [PR86] G. Pruesse and F. Ruskey. Generating linear extensions fast. SIAM J. Computing, 23:1994, 373-386.
- [PR02] S. Pettie and V. Ramachandran. An optimal minimum spanning tree algorithm. J. ACM, 49:16–34, 2002.
- [Pra75] V. Pratt. Every prime has a succinct certificate. SIAM J. Computing, 4:214–220, 1975.
- [Pri57] R. C. Prim. Shortest connection networks and some generalizations. Bell System Technical Journal, 36:1389–1401, 1957.
- [Prü18] H. Prüfer. Neuer Beweis eines Satzes über Permutationen. Arch. Math. Phys., 27:742–744, 1918.
- [PS85] F. Preparata and M. Shamos. Computational Geometry. Springer-Verlag, New York, 1985.
- [PS98] C. Papadimitriou and K. Steiglitz. Combinatorial Optimization: Algorithms and Complexity. Dover Publications, 1998.
- [PS02] H. Prömel and A. Steger. The Steiner Tree Problem: a tour through graphs, algorithms, and complexity. Friedrick Vieweg and Son, 2002.
- [PS03] S. Pemmaraju and S. Skiena. Computational Discrete Mathematics: Combinatorics and Graph Theory with Mathematica. Cambridge University Press, New York, 2003.
- [PSL90] A. Pothen, H. Simon, and K. Liou. Partitioning sparse matrices with eigenvectors of graphs. SIAM J. Matrix Analysis, 11:430–452, 1990.
- [PSS07] F. Putze, P. Sanders, and J. Singler. Cache-, hash-, and space-efficient bloom filters. In Proc. 6th Workshop on Experimental Algorithms (WEA), LNCS 4525, pages 108–121, 2007.
- [PST07] S. Puglisi, W. Smyth, and A. Turpin. A taxonomy of suffix array construction algorithms. ACM Computing Surveys, 39, 2007.

- [PSW92] T. Pavlides, J. Swartz, and Y. Wang. Information encoding with twodimensional bar-codes. *IEEE Computer*, 25:18–28, 1992.
- [PT05] A. Pothen and S. Toledo. Cache-oblivious data structures. In D. Mehta and S. Sahni, editors, *Handbook of Data Structures and Applications*, pages 59:1–59:29. Chapman and Hall / CRC, 2005.
- [Pug86] G. Allen Pugh. Partitioning for selective assembly. Computers and Industrial Engineering, 11:175–179, 1986.
- [PV96] M. Pocchiola and G. Vegter. Topologically sweeping visibility complexes via pseudo-triangulations. Discrete and Computational Geometry, 16:419–543, 1996.
- [Rab80] M. Rabin. Probabilistic algorithm for testing primality. J. Number Theory, 12:128–138, 1980.
- [Rab95] F. M. Rabinowitz. A stochastic algorithm for global optimization with constraints. ACM Trans. Math. Softw., 21(2):194–213, June 1995.
- [Ram05] R. Raman. Data structures for sets. In D. Mehta and S. Sahni, editors, Handbook of Data Structures and Applications, pages 33:1–33:22. Chapman and Hall / CRC, 2005.
- [Raw92] G. Rawlins. Compared to What? Computer Science Press, New York, 1992.
- [RBT04] H. Romero, C. Brizuela, and A. Tchernykh. An experimental comparison of approximation algorithms for the shortest common superstring problem. In Proc. Fifth Mexican Int. Conf. in Computer Science (ENC'04), pages 27–34, 2004.
- [RC55] Rand-Corporation. A million random digits with 100,000 normal deviates. The Free Press, Glencoe, IL, 1955.
- [RD01] E. Reingold and N. Dershowitz. Calendrical Calculations: The Millennium Edition. Cambridge University Press, New York, 2001.
- [RDC93] E. Reingold, N. Dershowitz, and S. Clamen. Calendrical calculations II: Three historical calendars. Software – Practice and Experience, 22:383–404, 1993.
- [Rei72] E. Reingold. On the optimality of some set algorithms. *J. ACM*, 19:649–659, 1972.
- [Rei91] G. Reinelt. TSPLIB a traveling salesman problem library. ORSA J. Computing, 3:376–384, 1991.
- [Rei94] G. Reinelt. The traveling salesman problem: Computational solutions for TSP applications. In Lecture Notes in Computer Science 840, pages 172– 186. Springer-Verlag, Berlin, 1994.
- [RF06] S. Roger and T. Finley. JFLAP: An Interactive Formal Languages and Automata Package. Jones and Bartlett, 2006.
- [RFS98] M. Resende, T. Feo, and S. Smith. Algorithm 787: Fortran subroutines for approximate solution of maximum independent set problems using GRASP. ACM Transactions on Mathematical Software, 24:386–394, 1998.

- [RHG07] S. Richter, M. Helert, and C. Gretton. A stochastic local search approach to vertex cover. In *Proc. 30th German Conf. on Artificial Intelligence (KI-2007)*, 2007.
- [RHS89] A. Robison, B. Hafner, and S. Skiena. Eight pieces cannot cover a chess-board. Computer Journal, 32:567–570, 1989.
- [Riv92] R. Rivest. The MD5 message digest algorithm. RFC 1321, 1992.
- [RR99] C.C. Ribeiro and M.G.C. Resende. Algorithm 797: Fortran subroutines for approximate solution of graph planarization problems using GRASP. ACM Transactions on Mathematical Software, 25:341–352, 1999.
- [RS96] H. Rau and S. Skiena. Dialing for documents: an experiment in information theory. Journal of Visual Languages and Computing, pages 79–95, 1996.
- [RSA78] R. Rivest, A. Shamir, and L. Adleman. A method for obtaining digital signatures and public-key cryptosystems. Communications of the ACM, 21:120–126, 1978.
- [RSL77] D. Rosenkrantz, R. Stearns, and P. M. Lewis. An analysis of several heuristics for the traveling salesman problem. SIAM J. Computing, 6:563–581, 1977.
- [RSN+01] A. Rukihin, J. Soto, J. Nechvatal, M. Smid, E. Barker, S. Leigh, M. Levenson, M. Vangel, D. Banks, A. Heckert, J. Dray, and S. Vo. A statistical test suite for the validation of random number generators and pseudo random number generators for cryptographic applications. Technical Report Special Publication 800-22, NIST, 2001.
- [RSS02] E. Rafalin, D. Souvaine, and I. Streinu. Topological sweep in degenerate cases. In *Proc. 4th Workshop on Algorithm Engineering and Experiments* (ALENEX), pages 273–295, 2002.
- [RSST96] N. Robertson, D. Sanders, P. Seymour, and R. Thomas. Efficiently fourcoloring planar graphs. In Proc. 28th ACM Symp. Theory of Computing, pages 571–575, 1996.
- [RT81] E. Reingold and J. Tilford. Tidier drawings of trees. IEEE Trans. Software Engineering, 7:223–228, 1981.
- [Rus03] F. Ruskey. Combinatorial Generation. Manuscript in preparation. Draft available at http://www.1stworks.com/ref/RuskeyCombGen.pdf, 2003.
- [Ryt85] W. Rytter. Fast recognition of pushdown automata and context-free languages. Information and Control, 67:12–22, 1985.
- [RZ05] G. Robins and A. Zelikovsky. Improved Steiner tree approximation in graphs. Tighter Bounds for Graph Steiner Tree Approximation, pages 122– 134, 2005.
- [SA95] M. Sharir and P. Agarwal. Davenport-Schinzel sequences and their geometric applications. Cambridge University Press, New York, 1995.
- [Sah05] S. Sahni. Double-ended priority queues. In D. Mehta and S. Sahni, editors, Handbook of Data Structures and Applications, pages 8:1–8:23. Chapman and Hall / CRC, 2005.

- [Sal06] D. Salomon. Data Compression: The Complete Reference. Springer-Verlag, fourth edition, 2006.
- [Sam05] H. Samet. Multidimensional spatial data structures. In D. Mehta and S. Sahni, editors, Handbook of Data Structures and Applications, pages 16:1– 16:29. Chapman and Hall / CRC, 2005.
- [Sam06] H. Samet. Foundations of Multidimensional and Metric Data Structures. Morgan Kaufmann, 2006.
- [San00] P. Sanders. Fast priority queues for cached memory. ACM Journal of Experimental Algorithmics, 5, 2000.
- [Sav97] C. Savage. A survey of combinatorial gray codes. SIAM Review, 39:605–629, 1997.
- [Sax80] J. B. Saxe. Dynamic programming algorithms for recognizing small-bandwidth graphs in polynomial time. SIAM J. Algebraic and Discrete Methods, 1:363–369, 1980.
- [Say05] K. Sayood. Introduction to Data Compression. Morgan Kaufmann, third edition, 2005.
- [SB01] A. Samorodnitsky and A. Barvinok. The distance approach to approximate combinatorial counting. Geometric and Functional Analysis, 11:871–899, 2001.
- [Sch96] B. Schneier. Applied Cryptography: Protocols, Algorithms, and Source Code in C. Wiley, New York, second edition, 1996.
- [Sch98] A. Schrijver. Bipartite edge-coloring in O(δ m) time. SIAM J. Computing, 28:841–846, 1998.
- [SD75] M. Syslo and J. Dzikiewicz. Computational experiences with some transitive closure algorithms. *Computing*, 15:33–39, 1975.
- [SD76] D. C. Schmidt and L. E. Druffel. A fast backtracking algorithm to test directed graphs for isomorphism using distance matrices. J. ACM, 23:433– 445, 1976.
- [SDK83] M. Syslo, N. Deo, and J. Kowalik. Discrete Optimization Algorithms with Pascal Programs. Prentice Hall, Englewood Cliffs NJ, 1983.
- [Sed77] R. Sedgewick. Permutation generation methods. Computing Surveys, 9:137– 164, 1977.
- [Sed78] R. Sedgewick. Implementing quicksort programs. Communications of the ACM, 21:847–857, 1978.
- [Sed98] R. Sedgewick. Algorithms in C++, Parts 1-4: Fundamentals, Data Structures, Sorting, Searching, and Graph Algorithms. Addison-Wesley, Reading MA, third edition, 1998.
- [Sei04] R. Seidel. Convex hull computations. In J. Goodman and J. O'Rourke, editors, Handbook of Discrete and Computational Geometry, pages 495–512. CRC Press, 2004.
- [SF92] T. Schlick and A. Fogelson. TNPACK a truncated Newton minimization package for large-scale problems: I. algorithm and usage. ACM Trans. Math. Softw., 18(1):46–70, March 1992.

- [SFG82] M. Shore, L. Foulds, and P. Gibbons. An algorithm for the Steiner problem in graphs. Networks, 12:323–333, 1982.
- [SH75] M. Shamos and D. Hoey. Closest point problems. In Proc. Sixteenth IEEE Symp. Foundations of Computer Science, pages 151–162, 1975.
- [SH99] W. Shih and W. Hsu. A new planarity test. *Theoretical Computer Science*, 223(1-2):179-191, 1999.
- [Sha87] M. Sharir. Efficient algorithms for planning purely translational collision-free motion in two and three dimensions. In Proc. IEEE Internat. Conf. Robot. Autom., pages 1326–1331, 1987.
- [Sha04] M. Sharir. Algorithmic motion planning. In J. Goodman and J. O'Rourke, editors, Handbook of Discrete and Computational Geometry, pages 1037– 1064. CRC Press, 2004.
- [She97] J. R. Shewchuk. Robust adaptive floating-point geometric predicates. *Disc. Computational Geometry*, 18:305–363, 1997.
- [Sho05] V. Shoup. A Computational Introduction to Number Theory and Algebra. Cambridge University Press, 2005.
- [Sip05] M. Sipser. Introduction to the Theory of Computation. Course Technology, second edition, 2005.
- [SK86] T. Saaty and P. Kainen. The Four-Color Problem. Dover, New York, 1986.
- [SK99] D. Sankoff and J. Kruskal. Time Warps, String Edits, and Macromolecules: the theory and practice of sequence comparison. CSLI Publications, Stanford University, 1999.
- [SK00] R. Skeel and J. Keiper. Elementary Numerical computing with Mathematica. Stipes Pub Llc., 2000.
- [Ski88] S. Skiena. Encroaching lists as a measure of presortedness. BIT, 28:775–784, 1988.
- [Ski90] S. Skiena. Implementing Discrete Mathematics. Addison-Wesley, Redwood City, CA, 1990.
- [Ski99] S. Skiena. Who is interested in algorithms and why?: lessons from the stony brook algorithms repository. ACM SIGACT News, pages 65–74, September 1999.
- [SL07] M. Singh and L. Lau. Approximating minimum bounded degree spanning tree to within one of optimal. In Proc. 39th Symp. Theory Computing (STOC), pages 661–670, 2007.
- [SLL02] J. Siek, L. Lee, and A. Lumsdaine. The Boost Graph Library: user guide and reference manual. Addison Wesley, Boston, 2002.
- [SM73] L. Stockmeyer and A. Meyer. Word problems requiring exponential time. In Proc. Fifth ACM Symp. Theory of Computing, pages 1–9, 1973.
- [Smi91] D. M. Smith. A Fortran package for floating-point multiple-precision arithmetic. ACM Trans. Math. Softw., 17(2):273–283, June 1991.
- [Sno04] J. Snoeyink. Point location. In J. Goodman and J. O'Rourke, editors, Hand-book of Discrete and Computational Geometry, pages 767–785. CRC Press, 2004.

- [SR83] K. Supowit and E. Reingold. The complexity of drawing trees nicely. Acta Informatica, 18:377–392, 1983.
- [SR03] S. Skiena and M. Revilla. Programming Challenges: The Programming Contest Training Manual. Springer-Verlag, 2003.
- [SS71] A. Schönhage and V. Strassen. Schnelle Multiplikation grosser Zahlen. Computing, 7:281–292, 1971.
- [SS02] R. Sedgewick and M. Schidlowsky. Algorithms in Java, Parts 1-4: Fundamentals, Data Structures, Sorting, Searching, and Graph Algorithms. Addison-Wesley Professional, third edition, 2002.
- [SS07] K. Schurmann and J. Stoye. An incomplex algorithm for fast suffix array construction. Software: Practice and Experience, 37:309–329, 2007.
- [ST04] D. Spielman and S. Teng. Smoothed analysis: Why the simplex algorithm usually takes polynomial time. *J. ACM*, 51:385–463, 2004.
- [Sta06] W. Stallings. Cryptography and Network Security: Principles and Practice. Prentice Hall, fourth edition, 2006.
- [Str69] V. Strassen. Gaussian elimination is not optimal. Numerische Mathematik, 14:354–356, 1969.
- [SV87] J. Stasko and J. Vitter. Pairing heaps: Experiments and analysis. Communications of the ACM, 30(3):234–249, 1987.
- [SV88] B. Schieber and U. Vishkin. On finding lowest common ancestors: simplification and parallelization. SIAM J. Comput., 17(6):1253-1262, December 1988.
- [SW86a] D. Stanton and D. White. Constructive Combinatorics. Springer-Verlag, New York, 1986.
- [SW86b] Q. Stout and B. Warren. Tree rebalancing in optimal time and space. Comm. $ACM,\ 29:902-908,\ 1986.$
- [SWA03] S. Schlieimer, D. Wilkerson, and A. Aiken. Winnowing: Local algorithms for document fingerprinting. In Proc. ACM SIGMOD Int. Conf. on Management of data, pages 76–85, 2003.
- [Swe99] Z. Sweedyk. A 2.5-approximation algorithm for shortest superstring. SIAM J. Computing, 29:954–986, 1999.
- [SWM95] J. Shallit, H. Williams, and F. Moraine. Discovery of a lost factoring machine. *The Mathematical Intelligencer*, 17-3:41–47, Summer 1995.
- [Szp03] G. Szpiro. Kepler's Conjecture: How Some of the Greatest Minds in History Helped Solve One of the Oldest Math Problems in the World. Wiley, 2003.
- [Tam08] R. Tamassia. Handbook of Graph Drawing and Visualization. Chapman-Hall / CRC, 2008.
- [Tar95] G. Tarry. Le problème de labyrinthes. Nouvelles Ann. de Math., 14:187, 1895.
- [Tar72] R. Tarjan. Depth-first search and linear graph algorithms. SIAM J. Computing, 1:146–160, 1972.

- [Tar75] R. Tarjan. Efficiency of a good but not linear set union algorithm. J. ACM, 22:215–225, 1975.
- [Tar79] R. Tarjan. A class of algorithms which require non-linear time to maintain disjoint sets. J. Computer and System Sciences, 18:110–127, 1979.
- [Tar83] R. Tarjan. Data Structures and Network Algorithms. Society for Industrial and Applied Mathematics, Philadelphia, 1983.
- [TH03] R. Tam and W. Heidrich. Shape simplification based on the medial axis transform. In *Proc. 14th IEEE Visualization (VIS-03)*, pages 481–488, 2003.
- [THG94] J. Thompson, D. Higgins, and T. Gibson. CLUSTAL W: improving the sensitivity of progressive multiple sequence alignment through sequence weighting, position-specific gap penalties and weight matrix choice. Nucleic Acids Research, 22:4673–80, 1994.
- [Thi03] H. Thimbleby. The directed chinese postman problem. Software Practice and Experience,, 33:1081–1096, 2003.
- [Tho68] K. Thompson. Regular expression search algorithm. Communications of the ACM, 11:419–422, 1968.
- [Tin90] G. Tinhofer. Generating graphs uniformly at random. Computing, 7:235–255, 1990.
- [TNX08] K. Thulasiraman, T. Nishizeki, and G. Xue. The Handbook of Graph Algorithms and Applications, volume 1: Theory and Optimization. Chapman-Hall/CRC, 2008.
- [Tro62] H. F. Trotter. Perm (algorithm 115). Comm. ACM, 5:434–435, 1962.
- [Tur88] J. Turner. Almost all k-colorable graphs are easy to color. J. Algorithms, 9:63–82, 1988.
- [TV01] R. Tamassia and L. Vismara. A case study in algorithm engineering for geometric computing. Int. J. Computational Geometry and Applications, 11(1):15-70, 2001.
- [TW88] R. Tarjan and C. Van Wyk. An $O(n \lg \lg n)$ algorithm for triangulating a simple polygon. SIAM J. Computing, 17:143–178, 1988.
- [Ukk92] E. Ukkonen. Constructing suffix trees on-line in linear time. In *Intern. Federation of Information Processing (IFIP '92)*, pages 484–492, 1992.
- [Val79] L. Valiant. The complexity of computing the permanent. Theoretical Computer Science, 8:189–201, 1979.
- [Val02] G. Valiente. Algorithms on Trees and Graphs. Springer, 2002.
- [Van98] B. Vandegriend. Finding hamiltonian cycles: Algorithms, graphs and performance. M.S. Thesis, Dept. of Computer Science, Univ. of Alberta, 1998.
- [Vaz04] V. Vazirani. Approximation Algorithms. Springer, 2004.
- [VB96] L. Vandenberghe and S. Boyd. Semidefinite programming. SIAM Review, 38:49–95, 1996.
- [vEBKZ77] P. van Emde Boas, R. Kaas, and E. Zulstra. Design and implementation of an efficient priority queue. Math. Systems Theory, 10:99–127, 1977.

- [Vit01] J. Vitter. External memory algorithms and data structures: Dealing with massive data. ACM Computing Surveys, 33:209–271, 2001.
- [Viz64] V. Vizing. On an estimate of the chromatic class of a p-graph (in Russian). Diskret. Analiz, 3:23–30, 1964.
- [vL90a] J. van Leeuwen. Graph algorithms. In J. van Leeuwen, editor, Handbook of Theoretical Computer Science: Algorithms and Complexity, volume A, pages 525–631. MIT Press, 1990.
- [vL90b] J. van Leeuwen, editor. Handbook of Theoretical Computer Science: Algorithms and Complexity, volume A. MIT Press, 1990.
- [VL05] F. Viger and M. Latapy. Efficient and simple generation of random simple connected graphs with prescribed degree sequence. In Proc. 11th Conf. on Computing and Combinatorics (COCOON), pages 440–449, 2005.
- [Vos92] S. Voss. Steiner's problem in graphs: heuristic methods. *Discrete Applied Mathematics*, 40:45 72, 1992.
- [Wal99] J. Walker. A Primer on Wavelets and Their Scientific Applications. CRC Press, 1999.
- [War62] S. Warshall. A theorem on boolean matrices. J. ACM, 9:11–12, 1962.
- [Wat03] B. Watson. A new algorithm for the construction of minimal acyclic DFAs. Science of Computer Programming, 48:81–97, 2003.
- [Wat04] D. Watts. Six Degrees: The Science of a Connected Age. W.W. Norton, 2004.
- [WBCS77] J. Weglarz, J. Blazewicz, W. Cellary, and R. Slowinski. An automatic revised simplex method for constrained resource network scheduling. ACM Trans. Math. Softw., 3(3):295–300, September 1977.
- [WC04a] B. Watson and L. Cleophas. Spare parts: a C++ toolkit for string pattern recognition. Software—Practice and Experience., 34:697–710, 2004.
- [WC04b] B. Wu and K Chao. Spanning Trees and Optimization Problems. Chapman-Hall / CRC, 2004.
- [Wei73] P. Weiner. Linear pattern-matching algorithms. In *Proc. 14th IEEE Symp.* on Switching and Automata Theory, pages 1–11, 1973.
- [Wei06] M. Weiss. Data Structures and Algorithm Analysis in Java. Addison Wesley, second edition, 2006.
- [Wel84] T. Welch. A technique for high-performance data compression. IEEE Computer, 17-6:8-19, 1984.
- [Wes83] D. H. West. Approximate solution of the quadratic assignment problem. ACM Trans. Math. Softw., 9(4):461–466, December 1983.
- [Wes00] D. West. Introduction to Graph Theory. Prentice-Hall, Englewood Cliffs NJ, second edition, 2000.
- [WF74] R. A. Wagner and M. J. Fischer. The string-to-string correction problem. J. ACM, 21:168–173, 1974.
- [Whi32] H. Whitney. Congruent graphs and the connectivity of graphs. American J. Mathematics, 54:150–168, 1932.

- [Wig83] A. Wigerson. Improving the performance guarantee for approximate graph coloring. J. ACM, 30:729–735, 1983.
- [Wil64] J. W. J. Williams. Algorithm 232 (heapsort). Communications of the ACM, 7:347–348, 1964.
- [Wil84] H. Wilf. Backtrack: An O(1) expected time algorithm for graph coloring. Info. Proc. Letters, 18:119–121, 1984.
- [Wil85] D. E. Willard. New data structures for orthogonal range queries. SIAM J. Computing, 14:232–253, 1985.
- [Wil89] H. Wilf. Combinatorial Algorithms: an update. SIAM, Philadelphia PA, 1989.
- [Win68] S. Winograd. A new algorithm for inner product. IEEE Trans. Computers, C-17:693-694, 1968.
- [Win80] S. Winograd. Arithmetic Complexity of Computations. SIAM, Philadelphia, 1980.
- [WM92a] S. Wu and U. Manber. Agrep a fast approximate pattern-matching tool. In *Usenix Winter 1992 Technical Conference*, pages 153–162, 1992.
- [WM92b] S. Wu and U. Manber. Fast text searching allowing errors. *Comm. ACM*, 35:83–91, 1992.
- [Woe03] G. Woeginger. Exact algorithms for NP-hard problems: A survey. In Combinatorial Optimization Eureka! You shrink!, volume 2570 Springer-Verlag LNCS, pages 185–207, 2003.
- [Wol79] T. Wolfe. The Right Stuff. Bantam Books, Toronto, 1979.
- [WW95] F. Wagner and A. Wolff. Map labeling heuristics: provably good and practically useful. In Proc. 11th ACM Symp. Computational Geometry, pages 109–118, 1995.
- [WWZ00] D. Warme, P. Winter, and M. Zachariasen. Exact algorithms for plane Steiner tree problems: A computational study. In D. Du, J. Smith, and J. Rubinstein, editors, Advances in Steiner Trees, pages 81–116. Kluwer, 2000.
- [WY05] X. Wang and H. Yu. How to break MD5 and other hash functions. In EU-ROCRYPT, LNCS v. 3494, pages 19–35, 2005.
- [Yan03] S. Yan. Primality Testing and Integer Factorization in Public-Key Cryptography. Springer, 2003.
- [Yao81] A. C. Yao. A lower bound to finding convex hulls. J. ACM, 28:780–787, 1981.
- [Yap04] C. Yap. Robust geometric computation. In J. Goodman and J. O'Rourke, editors, Handbook of Discrete and Computational Geometry, pages 607–641. CRC Press, 2004.
- [YLCZ05] R Yeung, S-Y. Li, N. Cai, and Z. Zhang. Network Coding Theory. http://www.nowpublishers.com/, Now Publishers, 2005.
- [You67] D. Younger. Recognition and parsing of context-free languages in time $O(n^3)$. Information and Control, 10:189–208, 1967.

- [YS96] F. Younas and S. Skiena. Randomized algorithms for identifying minimal lottery ticket sets. *Journal of Undergraduate Research*, 2-2:88–97, 1996.
- [YZ99] E. Yang and Z. Zhang. The shortest common superstring problem: Average case analysis for both exact and approximate matching. *IEEE Trans. Information Theory*, 45:1867–1886, 1999.
- [Zar02] C. Zaroliagis. Implementations and experimental studies of dynamic graph algorithms. In Experimental algorithmics: from algorithm design to robust and efficient software, pages 229–278. Springer-Verlag LNCS, 2002.
- [ZL78] J. Ziv and A. Lempel. A universal algorithm for sequential data compression. IEEE Trans. Information Theory, IT-23:337–343, 1978.
- [ZS04] Z. Zaritsky and M. Sipper. The preservation of favored building blocks in the struggle for fitness: The puzzle algorithm. IEEE Trans. Evolutionary Computation, 8:443–455, 2004.
- [Zwi01] U. Zwick. Exact and approximate distances in graphs a survey. In *Proc.* 9th Euro. Symp. Algorithms (ESA), pages 33–48, 2001.

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