Manual del Programador Competitivo

Antti Laaksonen

Traducción 22 de febrero de 2021

Índice general

Prefacio	v
Bibliografía	1

Prefacio

El propósito de este libro es brindarle una sólida introducción a la programación competitiva. Se asume que el lector ya conoce los conceptos básicos de programación, pero no se necesita experiencia previa en la programación competitiva.

El libro está especialmente destinado a estudiantes que quieren aprender algoritmos y posiblemente participar en la Olimpiada Internacional de Informática (IOI) o en el Concurso Internacional de Programación Universitario (ICPC). Por supuesto, el libro también es adecuado para cualquier otra persona interesada en la programación competitiva.

Se necesita mucho tiempo para convertirse en un buen programador competitivo, pero también es una oportunidad para un gran aprendizaje. El lector puede estar seguro de que obtendrá una buena comprensión de los algoritmos si pasa tiempo leyendo el libro, resolviendo problemas y participando en concursos.

El libro está en continuo desarrollo. Puedes enviar comentarios sobre el libro al correo ahslaaks@cs.helsinki.fi.

Helsinki, Agosto 2019 Antti Laaksonen

Bibliografía

- [1] A. V. Aho, J. E. Hopcroft and J. Ullman. *Data Structures and Algorithms*, Addison-Wesley, 1983.
- [2] R. K. Ahuja and J. B. Orlin. Distance directed augmenting path algorithms for maximum flow and parametric maximum flow problems. *Naval Research Logistics*, 38(3):413–430, 1991.
- [3] A. M. Andrew. Another efficient algorithm for convex hulls in two dimensions. *Information Processing Letters*, 9(5):216–219, 1979.
- [4] B. Aspvall, M. F. Plass and R. E. Tarjan. A linear-time algorithm for testing the truth of certain quantified boolean formulas. *Information Processing Letters*, 8(3):121–123, 1979.
- [5] R. Bellman. On a routing problem. *Quarterly of Applied Mathematics*, 16(1):87–90, 1958.
- [6] M. Beck, E. Pine, W. Tarrat and K. Y. Jensen. New integer representations as the sum of three cubes. *Mathematics of Computation*, 76(259):1683–1690, 2007.
- [7] M. A. Bender and M. Farach-Colton. The LCA problem revisited. In *Latin American Symposium on Theoretical Informatics*, 88–94, 2000.
- [8] J. Bentley. *Programming Pearls*. Addison-Wesley, 1999 (2nd edition).
- [9] J. Bentley and D. Wood. An optimal worst case algorithm for reporting intersections of rectangles. *IEEE Transactions on Computers*, C-29(7):571–577, 1980.
- [10] C. L. Bouton. Nim, a game with a complete mathematical theory. *Annals of Mathematics*, 3(1/4):35–39, 1901.
- [11] Croatian Open Competition in Informatics, http://hsin.hr/coci/
- [12] Codeforces: On "Mo's algorithm", http://codeforces.com/blog/entry/20032
- [13] T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein. *Introduction to Algorithms*, MIT Press, 2009 (3rd edition).
- [14] E. W. Dijkstra. A note on two problems in connexion with graphs. *Numeris- che Mathematik*, 1(1):269–271, 1959.

- [15] K. Diks et al. Looking for a Challenge? The Ultimate Problem Set from the University of Warsaw Programming Competitions, University of Warsaw, 2012.
- [16] M. Dima and R. Ceterchi. Efficient range minimum queries using binary indexed trees. *Olympiad in Informatics*, 9(1):39–44, 2015.
- [17] J. Edmonds. Paths, trees, and flowers. *Canadian Journal of Mathematics*, 17(3):449–467, 1965.
- [18] J. Edmonds and R. M. Karp. Theoretical improvements in algorithmic efficiency for network flow problems. *Journal of the ACM*, 19(2):248–264, 1972.
- [19] S. Even, A. Itai and A. Shamir. On the complexity of time table and multicommodity flow problems. 16th Annual Symposium on Foundations of Computer Science, 184–193, 1975.
- [20] D. Fanding. A faster algorithm for shortest-path SPFA. *Journal of Southwest Jiaotong University*, 2, 1994.
- [21] P. M. Fenwick. A new data structure for cumulative frequency tables. *Software: Practice and Experience*, 24(3):327–336, 1994.
- [22] J. Fischer and V. Heun. Theoretical and practical improvements on the RMQ-problem, with applications to LCA and LCE. In *Annual Symposium on Combinatorial Pattern Matching*, 36–48, 2006.
- [23] R. W. Floyd Algorithm 97: shortest path. Communications of the ACM, 5(6):345, 1962.
- [24] L. R. Ford. Network flow theory. RAND Corporation, Santa Monica, California, 1956.
- [25] L. R. Ford and D. R. Fulkerson. Maximal flow through a network. *Canadian Journal of Mathematics*, 8(3):399–404, 1956.
- [26] R. Freivalds. Probabilistic machines can use less running time. In *IFIP* congress, 839–842, 1977.
- [27] F. Le Gall. Powers of tensors and fast matrix multiplication. In *Proceedings* of the 39th International Symposium on Symbolic and Algebraic Computation, 296–303, 2014.
- [28] M. R. Garey and D. S. Johnson. *Computers and Intractability: A Guide to the Theory of NP-Completeness*, W. H. Freeman and Company, 1979.
- [29] Google Code Jam Statistics (2017), https://www.go-hero.net/jam/17
- [30] A. Grønlund and S. Pettie. Threesomes, degenerates, and love triangles. In *Proceedings of the 55th Annual Symposium on Foundations of Computer Science*, 621–630, 2014.

- [31] P. M. Grundy. Mathematics and games. Eureka, 2(5):6–8, 1939.
- [32] D. Gusfield. Algorithms on Strings, Trees and Sequences: Computer Science and Computational Biology, Cambridge University Press, 1997.
- [33] S. Halim and F. Halim. Competitive Programming 3: The New Lower Bound of Programming Contests, 2013.
- [34] M. Held and R. M. Karp. A dynamic programming approach to sequencing problems. *Journal of the Society for Industrial and Applied Mathematics*, 10(1):196–210, 1962.
- [35] C. Hierholzer and C. Wiener. Über die Möglichkeit, einen Linienzug ohne Wiederholung und ohne Unterbrechung zu umfahren. *Mathematische Annalen*, 6(1), 30–32, 1873.
- [36] C. A. R. Hoare. Algorithm 64: Quicksort. Communications of the ACM, 4(7):321, 1961.
- [37] C. A. R. Hoare. Algorithm 65: Find. Communications of the ACM, 4(7):321–322, 1961.
- [38] J. E. Hopcroft and J. D. Ullman. A linear list merging algorithm. Technical report, Cornell University, 1971.
- [39] E. Horowitz and S. Sahni. Computing partitions with applications to the knapsack problem. *Journal of the ACM*, 21(2):277–292, 1974.
- [40] D. A. Huffman. A method for the construction of minimum-redundancy codes. *Proceedings of the IRE*, 40(9):1098–1101, 1952.
- [41] The International Olympiad in Informatics Syllabus, https://people.ksp.sk/~misof/ioi-syllabus/
- [42] R. M. Karp and M. O. Rabin. Efficient randomized pattern-matching algorithms. *IBM Journal of Research and Development*, 31(2):249–260, 1987.
- [43] P. W. Kasteleyn. The statistics of dimers on a lattice: I. The number of dimer arrangements on a quadratic lattice. *Physica*, 27(12):1209–1225, 1961.
- [44] C. Kent, G. M. Landau and M. Ziv-Ukelson. On the complexity of sparse exon assembly. *Journal of Computational Biology*, 13(5):1013–1027, 2006.
- [45] J. Kleinberg and É. Tardos. Algorithm Design, Pearson, 2005.
- [46] D. E. Knuth. *The Art of Computer Programming. Volume 2: Seminumerical Algorithms*, Addison–Wesley, 1998 (3rd edition).
- [47] D. E. Knuth. *The Art of Computer Programming. Volume 3: Sorting and Searching*, Addison–Wesley, 1998 (2nd edition).

- [48] J. B. Kruskal. On the shortest spanning subtree of a graph and the traveling salesman problem. *Proceedings of the American Mathematical Society*, 7(1):48–50, 1956.
- [49] V. I. Levenshtein. Binary codes capable of correcting deletions, insertions, and reversals. *Soviet physics doklady*, 10(8):707–710, 1966.
- [50] M. G. Main and R. J. Lorentz. An $O(n \log n)$ algorithm for finding all repetitions in a string. *Journal of Algorithms*, 5(3):422–432, 1984.
- [51] J. Pachocki and J. Radoszewski. Where to use and how not to use polynomial string hashing. *Olympiads in Informatics*, 7(1):90–100, 2013.
- [52] I. Parberry. An efficient algorithm for the Knight's tour problem. *Discrete Applied Mathematics*, 73(3):251–260, 1997.
- [53] D. Pearson. A polynomial-time algorithm for the change-making problem. *Operations Research Letters*, 33(3):231–234, 2005.
- [54] R. C. Prim. Shortest connection networks and some generalizations. *Bell System Technical Journal*, 36(6):1389–1401, 1957.
- [55] 27-Queens Puzzle: Massively Parallel Enumeration and Solution Counting. https://github.com/preusser/q27
- [56] M. I. Shamos and D. Hoey. Closest-point problems. In *Proceedings of the 16th Annual Symposium on Foundations of Computer Science*, 151–162, 1975.
- [57] M. Sharir. A strong-connectivity algorithm and its applications in data flow analysis. *Computers & Mathematics with Applications*, 7(1):67–72, 1981.
- [58] S. S. Skiena. The Algorithm Design Manual, Springer, 2008 (2nd edition).
- [59] S. S. Skiena and M. A. Revilla. *Programming Challenges: The Programming Contest Training Manual*, Springer, 2003.
- [60] SZKOpuł, https://szkopul.edu.pl/
- [61] R. Sprague. Über mathematische Kampfspiele. *Tohoku Mathematical Journal*, 41:438–444, 1935.
- [62] P. Stańczyk. *Algorytmika praktyczna w konkursach Informatycznych*, MSc thesis, University of Warsaw, 2006.
- [63] V. Strassen. Gaussian elimination is not optimal. *Numerische Mathematik*, 13(4):354–356, 1969.
- [64] R. E. Tarjan. Efficiency of a good but not linear set union algorithm. *Journal* of the ACM, 22(2):215–225, 1975.
- [65] R. E. Tarjan. Applications of path compression on balanced trees. *Journal of the ACM*, 26(4):690–715, 1979.

- [66] R. E. Tarjan and U. Vishkin. Finding biconnected components and computing tree functions in logarithmic parallel time. In *Proceedings of the 25th Annual Symposium on Foundations of Computer Science*, 12–20, 1984.
- [67] H. N. V. Temperley and M. E. Fisher. Dimer problem in statistical mechanics an exact result. *Philosophical Magazine*, 6(68):1061–1063, 1961.
- [68] USA Computing Olympiad, http://www.usaco.org/
- [69] H. C. von Warnsdorf. Des Rösselsprunges einfachste und allgemeinste Lösung. Schmalkalden, 1823.
- [70] S. Warshall. A theorem on boolean matrices. *Journal of the ACM*, 9(1):11–12, 1962.