Appendix A

Some Useful Links and Software Sites on Optimization

A.1 General Optimization/Operations Research Sites

1. Optimization FAQ (LP and NLP FAQ) [14] contains a lot of information and html links concerning available software tools for LP and NLP, both commercial and non-commercial.

2. INFORMS OR/MS Resource Page (aka Michael Trick's Operations Research Page) [38] is an excellent www page for general information on operations research. This includes many links to OR-related societies, journals, software and online FAQs.

A.2 LP References

1. The earliear history of linear programming presented in Section 1.5 is mainly taken from Dantzig's classical book [8].

2. Some of the best books on the theory of Linear Programming are [35, 4, 39].

3. The proof of the strong duality theorem in Chapter 4 is quite unique, and its ideas can be found in [16, 19].

4. Our presentation of interior-point methods for linear programming in Chapter 10 is based on the excellent book [41] which contain detailed analyses of polynomial-time interior-point algorithms.

5. As it was discussed in Section 4.8, whether or not there is a polynomial-time pivot algorithm for linear programming is a widely open problem. There are subexponential bounds known for certain randomized (dual) simplex algorithms, see [24, 25, 22, 37]. An implementation and computational experiments were reported in [11, 12].

   There is a quite different approach to target a polynomial-time algorithm that uses admissible pivots (described in Figure 4.4). The criss-cross method is of this type.

Some positive results have been given in [18, 20], showing that there are very short (linear-length) admissible pivot paths from any basic solution to an optimal basic solution. Conjecture 4.20 on the polynomiality of the randomized criss-cross method is presented in a more general framework of linear complementarity in [13].

A.3 Complexity Theory References

1. Some of the best books on complexity theory are [1, 21, 32].
2. Stephan Cook's account of complexity theory is in [5].

A.4 Combinatorial Optimization References

1. Edmonds' polynomial algorithms for the minimum-cost matchings was given in [9].
2. A polynomial algorithm for the Chinese postman problem was given in [10].
3. Some of the excellent books on combinatorial optimizations are [35, 6, 23, 36]. There are a few classical books, e.g. [29, 33] that are still very useful.
4. To learn network flows and algorithms in depth, [2] is a great source.
5. Our account of approximation algorithms is largely based on an excellent book [40].

A.5 Useful Solvers and Libraries

1. One of the most efficient exact code, Concorde, for solving TSP is available from [3]. It contains a heuristic algorithm by Lin-Kernighan. A very efficient implementation of Edmonds' minimum-weight matching algorithm is available from [7], which uses the Concorde library. Recently, further improvements have been made with an implementation (requiring LEDA) reported to be even faster, see [31].
2. A parallel library of search algorithms, such as branch-and-bound, back track search, reverse search, is available at [30]. This library can be used to implement a B&B algorithm or an enumeration algorithm to run in parallel on networked workstations or on a parallel computers without knowing parallel computation.

Bibliography

[1] A.V. Aho, J.E. Hopcroft, and J.D. Ullman. *The design and analysis of computer algorithms*. Addison-Wesley, 1974.

[2] R. K. Ahuja, T. L. Magnanti, and J. B. Orlin. *Network flows*. Prentice Hall Inc., Englewood Cliffs, NJ, 1993. Theory, algorithms, and applications.

[3] D. Applegate, R.E. Bixby, V. Chvátal, and W.J. Cook. Concorde - a code for solving traveling salesman problems. http://www.tsp.gatech.edu/concorde.html.

[4] V. Chvatal. *Linear Programming*. W.H.Freeman and Company, 1983.

[5] S.A. Cook. An overview of computational complexity (Turing Award Lecture). *Communications of the ACM*, 26:401–408, 1983.

[6] W.J. Cook, W.H. Cunningham, W.R. Pullyblank, and A. Schrijver. *Combinatorial optimization*. Series in Disctrete Mathematics and Optimization. John Wiley & Sons, 1998.

[7] W.J. Cook and A. Rohe. Blossom IV - a minimum weighted perfect matching solver. http://www.isye.gatech.edu/˜wcook/.

[8] G.B. Dantzig. *Linear Programming and Extensions*. Princeton University Press, Princeton, New Jersey, 1963.

[9] J. Edmonds. Path, trees, and flowers. *Canadian J. Math.*, 17:449–467, 1965.

[10] J. Edmonds and E.L. Johnson. Matching, Euler tours and the Chinese postman. *Mathematical Programming*, 5:88–124, 1973.

[11] L. Finschi. Randomized pivot algorithms in linear programming. Deploma Thesis, Swiss Federal Institute of Technology, Zurich, 1997. awarded a Walter Saxer-Versicherungs-Hochschulpreise for the year 1997.

[12] L. Finschi, K. Fukuda, and H.-J. Lüthi. Towards a unified framework for randomized pivoting algorithms in linear programming. In P. Kall and H.-J. Lüthi, editors, *Operations Research Proceedings 1998*, pages 113–122, 1999. ps file available from ftp://ftp.ifor.math.ethz.ch/pub/fukuda/reports/randsimp9810.ps.gz.

[13] J. Foniok, K. Fukuda, B. Gärtner, and H.-J. Lüthi. Pivoting in linear complementarity: two polynomial-time cases. *Discrete Comput. Geom.*, 42:187–205, 2009. http://arxiv.org/abs/0807.1249.

[14] R. Fourer and J.W. Gregory. Optimization frequently asked questions (lp and nlp faq). http://www-unix.mcs.anl.gov/otc/Guide/faq/.

[15] O. Friedmann, T. Hansen, and U. Zwick. Subexponential lower bounds for randomized pivoting rules for the simplex algorithm. In *STOC*, pages 283–292, 2011.

[16] K. Fukuda. *Oriented matroid programming.* Ph.D. thesis, Univ. of Waterloo, Waterloo, Canada, 1982. ftp://ftp.ifor.math.ethz.ch/pub/fukuda/reports/fukuda1982thesis.pdf.

[17] K. Fukuda. Walking on the arrangement, not on the feasible region. Efficiency of the Simplex Method: Quo vadis Hirsch conjecture?, IPAM, UCLA, 2011. presentation slides available as https://www.ipam.ucla.edu/schedule.aspx?pc=sm2011.

[18] K. Fukuda, H.-J. Lüthi, and M. Namiki. The existence of a short sequence of admissible pivots to an optimal basis in LP and LCP. *Int. Trans. Opl. Res.*, 4:273–284, 1997.

[19] K. Fukuda and T. Terlaky. Criss-cross methods: A fresh view on pivot algorithms. *Mathematical Programming*, 79:369–395, 1997.

[20] K. Fukuda and T. Terlaky. On the existence of a short admissible pivot sequence for feasibility and linear optimization problems. *Pure Mathematics and Applications, Mathematics of Optimization*, 10(4):431–447, 2000. pdf file available at ftp://ftp.ifor.math.ethz.ch/pub/fukuda/reports/short000214.pdf.

[21] M. R. Garey and D. S. Johnson. *Computers and Intractability.* W. H. Freeman, 1979.

[22] J.E. Goodman and J. O'Rourke (eds.). *Handbook of Discrete and Computational Geometry.* CRC Press, 1997.

[23] M. Grötschel, L. Lovász, and A. Schrijver. *Geometric algorithms and combinatorial optimization.* Springer-Verlag, Berlin, 1988.

[24] G. Kalai. Linear programming, the simplex algorithm and simple polytopes. *Math. Programming*, 79(1-3, Ser. B):217–233, 1997. Lectures on mathematical programming (ismp97) (Lausanne, 1997), ps file available from http://www.ma.huji.ac.il/~kalai/papers.html.

[25] G. Kalai and D. Kleitman. A quasi-polynomial bound for the diameter of graphs of polyhedra. *Bull. Amer. Math. Soc.*, 26:315–316, 1992.

[26] N. Karmarkar. A new polynomial-time algorithm for linear programming. *Combinatorica*, 4:373–395, 1984.

[27] L.G. Khachiyan. A polynomial algorithm in linear programming. *Dokklady Akademiia Nauk SSSR*, 244:1093–1096, 1979.

[28] V. Klee and G. J. Minty. How good is the simplex algorithm? In *Inequalities, III (Proc. Third Sympos., Univ. California, Los Angeles, Calif., 1969; dedicated to the memory of Theodore S. Motzkin)*, pages 159–175. Academic Press, New York, 1972.

[29] E. L. Lawler. *Combinatorial optimization: networks and matroids.* Holt, Rinehart and Winston, New York, 1976.

[30] A. Marzetta. ZRAM homepage. http://www.cs.unb.ca/profs/bremner/zram/.

[31] K. Mehlhorn and G. Schäfer. Implementation of $O(nm \log n)$ weighted matchings in general graphs: the power of data structures. *ACM J. Exp. Algorithmics*, 7:19 pp. (electronic), 2002. Fourth Workshop on Algorithm Engineering (Saarbrücken, 2000).

[32] C.H. Papadimitriou. *Computational Complexity*. Addison-Wesley, 1994.

[33] C.H. Papadimitriou and K. Steiglitz. *Combinatorial Optimization*. Printice-Hall, 1982.

[34] F. Santos. A counter-example to the Hirsch conjecture. Preprint, 2010. http://arxiv.org/abs/1006.2814.

[35] A. Schrijver. *Theory of linear and integer programming*. John Wiley & Sons, New York, 1986.

[36] A. Schrijver. *Combinatorial optimization. Polyhedra and efficiency. Vol. A, B, C*, volume 24 of *Algorithms and Combinatorics*. Springer-Verlag, Berlin, 2003.

[37] M. Sharir and E. Welzl. A combinatorial bound for linear programming and related problems. In *STACS 92 (Cachan, 1992)*, volume 577 of *Lecture Notes in Comput. Sci.*, pages 569–579. Springer, Berlin, 1992.

[38] INFORMS (M. Trick). OR/MS resource collection (Michael Trick's operations research page). http://www.informs.org/Resources/.

[39] R. J. Vanderbei. *Linear programming: Foundations and extensions*. International Series in Operations Research & Management Science, 37. Kluwer Academic Publishers, Boston, MA, second edition, 2001.

[40] V. V. Vazirani. *Approximation algorithms*. Springer-Verlag, Berlin, 2001.

[41] S. J. Wright. *Primal-dual interior-point methods*. Society for Industrial and Applied Mathematics (SIAM), Philadelphia, PA, 1997.