Simple

Eva Rotenberg
Technical University of Denmark, Lyngby, Denmark

Abstract

Simplicity in algorithms has various aspects; interpretations and implications. One is the simplicity of the algorithmic solution itself: if an algorithm (or data structure) has a brief verbal description or can be written with few lines of pseudocode, this can lead to easier, more robust, and possibly more efficient implementations. Another aspect of simplicity relates to the proofs of correctness and efficiency of our algorithmic solutions. Here, we experience that algorithms and data structures with simpler proofs of statements about their properties can be easier to understand, easier to teach, and sometimes, easier to generalise. Simplification of proofs also receives attention in mathematics; here, too, simplification has benefits to clarity of exposition and possibility of generalisation. There are even examples of proof simplification leading to the design of new and more efficient algorithms.

This talk will present examples illustrating these various aspects of simplicity. Examples where algorithmic simplification or proof simplification has led to improved performance of algorithms and data structures, in theory, in practice, or both.

Finally, some of the most attractive questions in discrete mathematics and in theory of computing have a property in common: they are very simple to pose, but surprisingly, to our knowledge, not very simple to answer. The talk will include examples of such questions, which I leave as an open problem for the audience.

2012 ACM Subject Classification Theory of computation → Design and analysis of algorithms

Keywords and phrases Simplicity, graph algorithms, computational geometry, algorithmic simplification, data structures, combinatorics, proof simplification, dynamic graphs

Digital Object Identifier 10.4230/LIPIcs.ESA.2024.2

Category Invited Talk

Funding DFF Grant 2020-2023 (9131-00044B) "Dynamic Network Analysis", VILLUM Foundation grant VIL37507 "Efficient Recomputations for Changeful Problems", and Carlsberg Foundation Young Researcher Fellowship CF21-0302 "Graph Algorithms with Geometric Applications".

Acknowledgements I am grateful to colleagues and coauthors for inspiration and ideas.

References

1. Stephen Alstrup, Agelos Georgakopoulos, Eva Rotenberg, and Carsten Thomassen. A Hamiltonian cycle in the square of a 2-connected graph in linear time. In Artur Czumaj, editor, *SODA 2018, New Orleans, January 7-10*, pages 1645–1649. SIAM, 2018. doi:10.1137/1.9781611975031.107.
2. Uwe Baier. Linear-time suffix sorting - A new approach for suffix array construction. In Roberto Grossi and Moshe Lewenstein, editors, *CPM 2016, Tel Aviv, June 27-29*, volume 54 of *LIPIcs*, pages 23:1–23:12. LIPIcs, 2016. doi:10.4230/LIPICS.CPM.2016.23.
3. Hideo Bannai and Jonas Ellert. Lyndon arrays in sublinear time. In Inge Li Gørtz, Martin Farach-Colton, Simon J. Puglisi, and Grzegorz Herman, editors, *ESA 2023, Amsterdam, September 4-6*, volume 274 of *LIPIcs*, pages 14:1–14:16. LIPIcs, 2023. doi:10.4230/LIPICS.ESA.2023.14.
4. Aaron Bernstein, Jacob Holm, and Eva Rotenberg. Online bipartite matching with amortized $O(\log^2 n)$ replacements. In Artur Czumaj, editor, *SODA 2018, New Orleans, January 7-10*, pages 947–959. SIAM, 2018. doi:10.1137/1.9781611975031.61.

5 Philip Bille, Jonas Ellert, Johannes Fischer, Inge Li Gørtz, Florian Kurpicz, J. Ian Munro, and Eva Rotenberg. Space efficient construction of lyndon arrays in linear time. In Artur Czumaj, Anuj Dawar, and Emanuela Merelli, editors, *ICALP 2020, July 8-11*, volume 168 of *LIPIcs*, pages 14:1–14:18. LIPIcs, 2020. doi:10.4230/LIPIcs.ICALP.2020.14.

6 Bartlomiej Bosek, Dariusz Leniowski, Piotr Sankowski, and Anna Zych. Online bipartite matching in offline time. In *FOCS 2014, Philadelphia, October 18-21*, pages 384–393. IEEE Computer Society, 2014. doi:10.1109/FOCS.2014.48.

7 Aleksander B. G. Christiansen, Eva Rotenberg, and Daniel Rutschmann. Triangulations admit dominating sets of size $2n/7$. In David P. Woodruff, editor, *SODA 2024, Alexandria, January 7-10*, pages 1194–1240. SIAM, 2024. doi:10.1137/1.9781611977912.47.

8 Aleksander Bjørn Grodt Christiansen, Krzysztof Nowicki, and Eva Rotenberg. Improved dynamic colouring of sparse graphs. In Barna Saha and Rocco A. Servedio, editors, *STOC 2023, Orlando, June 20-23*, pages 1201–1214. ACM, 2023. doi:10.1145/3564246.3585111.

9 Jonas Ellert. Lyndon arrays simplified. In Shiri Chechik, Gonzalo Navarro, Eva Rotenberg, and Grzegorz Herman, editors, *ESA 2022, Berlin/Potsdam, September 5-9*, volume 244 of *LIPIcs*, pages 48:1–48:14. LIPIcs, 2022. doi:10.4230/LIPICS.ESA.2022.48.

10 Herbert Fleischner. The square of every two-connected graph is hamiltonian. *Journal of Combinatorial Theory, Series B*, 16(1):29–34, 1974. doi:10.1016/0095-8956(74)90091-4.

11 Emil Toftegaard Gæde, Inge Li Gørtz, Ivor van der Hoog, Christoffer Krogh, and Eva Rotenberg. Simple and robust dynamic two-dimensional convex hull. In Rezaul Chowdhury and Solon P. Pissis, editors, *ALENEX 2024, Alexandria, January 7-8*, pages 144–156. SIAM, 2024. doi:10.1137/1.9781611977929.11.

12 Agelos Georgakopoulos. A short proof of fleischner's theorem. *Discret. Math.*, 309(23-24):6632–6634, 2009. doi:10.1016/J.DISC.2009.06.024.

13 Mohsen Ghaffari and Christoph Grunau. Dynamic o(arboricity) coloring in polylogarithmic worst-case time. In Bojan Mohar, Igor Shinkar, and Ryan O'Donnell, editors, *STOC 2024, Vancouver, June 24-28*, pages 1184–1191. ACM, 2024. doi:10.1145/3618260.3649782.

14 Edward F. Grove, Ming-Yang Kao, P. Krishnan, and Jeffrey Scott Vitter. Online perfect matching and mobile computing. In Selim G. Akl, Frank K. H. A. Dehne, Jörg-Rüdiger Sack, and Nicola Santoro, editors, *WADS '95, Kingston, August 16-18*, volume 955 of *Lecture Notes in Computer Science*, pages 194–205. Springer, 1995. doi:10.1007/3-540-60220-8_62.

15 Lesley R. Matheson and Robert Endre Tarjan. Dominating sets in planar graphs. *Eur. J. Comb.*, 17(6):565–568, 1996. doi:10.1006/EUJC.1996.0048.

16 Mark H. Overmars and Jan van Leeuwen. Dynamically maintaining configurations in the plane (detailed abstract). In Raymond E. Miller, Seymour Ginsburg, Walter A. Burkhard, and Richard J. Lipton, editors, *STOC 1980, Los Angeles, April 28-30*, pages 135–145. ACM, 1980. doi:10.1145/800141.804661.

17 Simon Spacapan. The domination number of plane triangulations. *J. Comb. Theory B*, 143:42–64, 2020. doi:10.1016/J.JCTB.2019.11.005.

18 Stanislav Řiha. A new proof of the theorem by fleischner. *Journal of Combinatorial Theory, Series B*, 52(1):117–123, 1991. doi:10.1016/0095-8956(91)90098-5.