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ANANY LEVITIN'S COLLECTION OF ALGORITHMIC PUZZLES AS MATHEMATICAL RECREATIONS

Summary: Anany Levitin (1947–2021) is the author of the textbook *Introduction to the Design and Analysis of Algorithms* and a co-author (with Maria Levitin) of *Algorithmic Puzzles*. This paper outlines how Levitin collected and classified 'algorithmic puzzles' as mathematical recreations and how these puzzles were promoted as a teaching tool in algorithm courses, inspiring educators to incorporate puzzle-like problems into computer science pedagogy.

Keywords: mathematical recreations, algorithms

Recreational mathematics is a channel
between the mathematical community and the general public.
David Singmaster (1938–2023)

Introduction

Skills of algorithmic thinking are useful for designing computational solutions to problems in many areas of the modern world, and no computer programmer will deny that. Interestingly, algorithmic puzzles, i.e. 'puzzles that involve explicitly or implicitly, clearly defined procedures for solving problems'[1], predate computers by tens or even hundreds of years[2]. Such mathematical recreations may be crucial from a pedagogical point of view in the 21st c.

[1] A. Levitin, M. Levitin, *Algorithmic puzzles*, Oxford University Press, New York 2011, p. ix.

[2] The river-crossing puzzles are attributed to Alcuin of York (ca. 735–804 CE). In 1735, Euler proved that it was impossible to walk through all seven bridges of Königsberg without crossing the same bridge more than once. Hamilton (1805−1865) invented the Icosian Game. In 1883, Lucas invented a puzzle called the Tower of Hanoi. In A. Levitin, M. Levitin, *Algorithmic puzzles*, the authors discuss classic problems posed by Hugo Steinhaus in 1958: the Abacus Problem and the Longest Route.

Digging for algorithmic puzzles

Puzzles used in textbooks to illustrate various ideas in algorithmic problem-solving include: the Guessing Game (binary search), the Tower of Hanoi (a recursive algorithm), the Königsberg Bridge (Euler circuits), mazes (depth-first search), and the 8 Queens Puzzle (backtracking).

Thanks to Anany Levitin's[3] long-term work, the list is now much longer. He looked for algorithmic problems in collections of puzzles, in categories like one-to-one correspondence, coin weighing, decanting (pouring water), game strategies, patterns, river crossing, etc.

In a SIGCSE 2002 conference paper sharing their experiences as lecturers at Villanova University, Anany Levitin and his colleague wrote that puzzles 'force students to think about algorithms on a more abstract level, divorced from programming and computer language minutiae'[4]. The paper advocated a wider use of puzzles in teaching about algorithms.

Algorithmic puzzles were included by Anany Levitin in his textbook *Introduction to the Design and Analysis of Algorithms*, first published in 2002[5], which at the time covered the material required in an introductory university course in algorithmics. Subsequent editions are now in widespread use in hundreds of universities all over the world.

The book *Algorithmic Puzzles* by Anany and Maria Levitin, published in 2011, contained a tutorial with 22 example puzzles and 150 additional puzzles, divided into three levels of difficulty.

One of the new puzzles by A. Levitin is Schweik's Puzzle:

> The good soldier Schweik had been ordered to line up a band of new recruits […]. The desired line sought to minimize the average difference in height of adjacent men. Schweik put the tallest recruit first, the shortest one last, and let the remaining men stand between them in random order. Did Schweik execute his order as stated?[6]

In 2017, A. Levitin wrote an article for the "Journal of Problem Solving"[7] in which he reviewed the major milestones in the history of algorithmic puzzles and

[3] Anany Levitin held a PhD in mathematics from the Hebrew University of Jerusalem and an MS in computer science from the University of Kentucky (USA). He wrote his books as a professor at Villanova University.

[4] A. Levitin, M.-A. Papalaskari, *Using puzzles in teaching algorithms*, [in:] *Proceedings of the 33rd SIGCSE technical symposium on computer science education*, ed. by J.L. Gersting, H.M. Walker, S. Grissom, ACM, New York 2002, p. 295.

[5] A. Levitin, *Introduction to the Design and Analysis of Algorithms*, Addison-Wesley Longman Publishing Co., Inc., Boston 2002.

[6] A. Levitin, M. Levitin, *Algorithmic puzzles*, p. 46 (no. 56).

[7] A. Levitin, *Algorithmic Puzzles: History, Taxonomies, and Applications in Human Problem Solving*, "The Journal of Problem Solving" 2017, vol. 10, no. 1, p. 1–15.

listed puzzles that might be useful for future research on the cognitive aspects of solving algorithmic puzzles.

Concluding remarks

No more than a high school level of mathematics is required to solve the puzzles from Levitin's collection. For this reason, Martin Griffiths, reviewer for "The Mathematical Gazette", recommended *Algorithmic Puzzles* to schoolteachers[8]. However, puzzle-like problems should not be confined only to lessons on algorithmics in computer science classes. Young people could benefit greatly from using algorithmic puzzles as mathematical recreations.

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[8] M. Griffiths, *Reviews. Algorithmic puzzles, by Anany Levitin and Maria Levitin*, "The Mathematical Gazette" 2014, vol. 98, no. 541, p. 188.