Nonograms

A *Nonogram*, also known as a *Japanese puzzle* in some countries, is a kind of logic puzzle, where the goal is to draw a rectangular image that adheres to certain row and column constraints. Usually, the image is black-and-white, although Nonograms with more than two grey values exist as well.

	1	1, 1	1	1, 1	1
1, 1					
ϵ					
1, 1					
3					

0	1	0	1	0
0	0	0	0	0
x	x	0	x	x
x	x	1	x	x

	●		●	
●				●
	●	●	●	

Figure 1: A simple 4×5 Nonogram: a) original puzzle; b) partial solution (`1` = black, `0` = white, `x` = yet unknown), after just using single line information; c) final solution (dots denote black pixels)

Figure 1 shows an example of a Nonogram. The puzzle has a rectangular shape, subdivided into unit cells, also referred to as *pixels*. For each row and each column, a *description* is given. The description indicates the lengths of the consecutive segments of black pixels along the corresponding line. For example, the description "1, 1" in the first row indicates that when traversing the pixels in that row from left to right, there should first be zero or more white pixels, followed by one black pixel. Then, at least one white pixel must occur, followed by exactly one black pixel. There may be additional white pixels at the end of the line. Note that the lengths are ordered, so a description "3, 2" means that first a block of 3 black pixels is encountered, and then one of 2 black pixels, separated by at least one white pixel. The symbol ϵ denotes the empty description, leading to an all white line. The goal of the puzzle is to colour all pixels with either black or white, in such a way that each horizontal and vertical line is consistent with the given description.
When using only information concerning single rows and columns, puzzles can often be partially solved (see the second picture in Figure 1). For instance, one can infer that the middle pixel in the bottom row must be black.
It is important to realize that a good puzzle should have a unique solution. In the background we have an *NP-complete* problem; by trying all possible solutions in a brute-force way the puzzles can be solves in principle. It is easy to verify a proposed solution, but finding it can be very hard. The problem is related to *Computer Tomography*, where it is required to reconstruct images from so-called *projections*, analogous to the numbers besides Nonograms.

K. J. Batenburg and W. A. Kosters, On the Difficulty of Nonograms, ICGA Journal 35 (2012), 195–205.
K.J. Batenburg and W.A. Kosters, Nonograms, Nieuwsbrief van de Nederlandse Vereniging voor Theoretische Informatica 16 (2012), 49–62 [in Dutch].

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