**Nonograms resolution model**

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# **Introduction**

A picture containing text, shoji, crossword puzzle

Description automatically generatedA picture containing text, crossword puzzle

Description automatically generatedA Nonogram, also known as Japanese puzzle or Picross, is a logical puzzle where one has to recreate an image following some constraints. The puzzle is given on an empty rectangle, divided by a given number of rows and columns, forming cells. We will refer at these cells as *pixels*. Each row and column, or simply *line*, contain a *description* of its content. This description may contain one or several numbers, representing the number of successive pixels which must be filled. Each group of pixels, which we will called *block* after, must be separated by at least one empty pixel, and they must follow the order specify on the description. As an example, the description “3 1” means the associated line must contains a group of three successive filled pixels, at least one empty pixel, followed by a single filled pixel. There can also be any number of empty pixels before the first group, as well as after the last one, but there can’t be any other filled pixels than those mentioned on the description. The final goal is to fill every pixel while following the constraints on each and every lines.

Fig.1. An example of an empty nonogram to the left, and its unique solution to the right

According to [1], solving a general Nonogram is NP-hard. However, if we focus only on simple Nonogram, with a unique solution, such as those publish on some magazines, it is possible to find a solution on a polynomial time. In fact, most of the lines can be solved using only the description of the line, and the already available pixels.

# **Proposed model**

We can define the set of values a pixel can hold as , where 0 means an empty pixel, while 1 is a filled pixel. We can also define , where ? represents a pixel whose value is still unknow.

The description of a line is composed of a succession of block of value x ∈ N. Some blocks are of size fixed, the blocks of filled pixels, while some others have a variable size, the blocks of empty pixels. Therefore, we should define a description δ as a list of triplets (xi, ai, bi), where xi is the value of the group, while ai and bi are respectively the minimal and maximal size of the group. By example, for the description “3 1” previously mentioned, the description would be , where ∞ represent the largest possible number.

We can then describe the body of the Nonogram as a table of size n x m, where n is the number of rows and m the number of columns. This table can contains any value from N’, while being initially filled with ?. We can now define the line li bounds to the description δi, as the row i or the column (i-n) of the table, for any i such as 1 ≤ i ≤ n+m.

Therefore, a Nonogram can be define as a pair (D, P), where D is the list of descriptions δ of the puzzle, and P is the table containing its result.

## **References**

1. K.J. Batenburg and W.A. Kosters. A Reasoning Framework for Solving Nonograms. In Combinatorial Image Analysis, pages 372-383, 2008
2. Jan van Rijn. Playing Games The complexity of Klondike, Mahjong, Nonograms and Animal Chess. 2012