Solver of Tricky Triple Puzzles Based on Constraint Programming

`up201303828@fe.up.pt` Ângelo Daniel Pereira Mendes Moura
`up201806528@fe.up.pt` Clara Alves Martins

Faculty of Engineering of the University of Porto
https://www.fe.up.pt

Logic Programming
3MIEIC06 - Tricky Triple 2

January 4, 2021

Abstract. In this article, we show how to use constraint programming to solve Tricky Triple Puzzles. We present a consistent method to analyze these puzzles and to obtain a solution to them.

Keywords: tricky-triple · prolog · clpfd · constraint-programming

1 Introduction

This project consists of building a program, in Logic Programming with Restrictions, for solving a combinatorial decision. The problems studied are Tricky Triple Puzzles, which are grid puzzles. To do so, we will analyze these problems and proceed to implement our solver using SICStus Prolog. Afterward, we will be discussing the performance results obtained.

2 Problem Description

The Tricky Triple puzzles are a type of grid puzzle. The goal of the puzzle is to fill each of the grid's white cells with one of 3 symbols, a square, a circle, or a triangle. The only rule is that each group of 3 adjacent white cells (horizontally, vertically, or diagonally) must contain exactly 2 of one of the symbols. So, each group of 3 white cells will have 2 of 3 symbols. Each puzzle given has a unique solution.

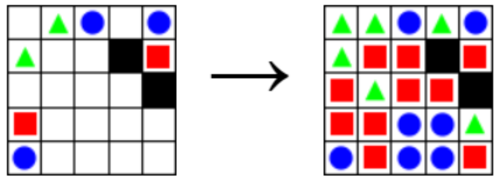

Fig. 1. Example of Tricky Triple Puzzles, before and after solving it

3 Approach

Throughout the development of this project, we used a Constraint Logic Programming approach. Our grid is a list of lists, where each element is a number indicating the symbol placed on that cell. Each one of these numbers represents a different symbol. The number 0 represents a black cell, which cannot be generated by the solver. The number 1 represents a green triangle, while the number 2 represents a red square and the number 3 a blue circle.

3.1 Decision Variables

All tricky triple puzzles take the form of an NxN square grid divided by cells. The grid is represented internally by a list of lists forming a square matrix.

The grid cells can either be black, a cell that the program can't fill, or, more commonly, white.

All the white cells need to be either a triangle (represented by 1), a square (represented by 2), or a circle (represented by 3) to reach the puzzle solution.

The Decision Variables are all the elements of the list of lists, meaning all the puzzle cells. Their domain is 0, 1, 2, 3. However, being the representative of a black cell, the zero is not considered a valid value to fill an empty cell, since that would transform a white cell into a black cell.

3.2 Constraints

The restrictions implemented in our solver are faithful to the ones from the puzzle rules.

Each cell must contain a symbol
In the puzzle solution, all the cells have to be assigned.

No black cells can be assigned
In every white cell, we need to put a square, a triangle, or a circle. Meaning we can't put a black cell on a white cell.

Each group of 3 adjacent white cells (horizontally, vertically, or diagonally) must contain exactly 2 of one of the symbols
Consider a group of three adjacent, horizontally, vertically, or diagonally, white cells. In this group, two of the cells have the same symbol, and the last cell must have a different one.

4 Solution Presentation

To present the solution, we use two predicates from the file *display.pl*.

- The predicate `display_grid/2` displays the grid in a human-friendly way so that the user can identify the cells and the grid's symbols.
- The predicate `get_readable_symbol/2` translates the grid elements' internal representation into more readable symbols for those to be displayed to the user.

```
*********************************
****                         ****
****      TRICKY TRIPLE      ****
****                         ****
*********************************
 Selected Puzzle:
   ---------------------
   |   | S |   | T |   |
   ---------------------
   |   |   |   |   |   |
   ---------------------
   | T |   |   |   | S |
   ---------------------
   |   |   | - |   |   |
   ---------------------
   | C | S |   | C | T |
   ---------------------

*********************************

 Obtained Solution:
   ---------------------
   | C | S | S | T | T |
   ---------------------
   | C | T | T | C | T |
   ---------------------
   | T | S | T | T | S |
   ---------------------
   | T | T | - | C | S |
   ---------------------
   | C | S | C | C | T |
   ---------------------

 Solution on Library:
   ---------------------
   | C | S | S | T | T |
   ---------------------
   | C | T | T | C | T |
   ---------------------
   | T | S | T | T | S |
   ---------------------
   | T | T | - | C | S |
   ---------------------
   | C | S | C | C | T |
   ---------------------

*********************************
  Time: 62 milliseconds
*********************************
```

Fig. 2. Output Example for a Puzzle Solution

5 Experiments and Results

In order to evaluate our solver,

5.1 Dimensional Analysis

5.2 Search Strategies

6 Conclusions and Future Work

7 Section Sample

7.1 A Subsection Sample

Please note that the first paragraph of a section or subsection is not indented. The first paragraph that follows a table, figure, equation etc. does not need an indent, either.

Subsequent paragraphs, however, are indented.

Sample Heading (Third Level) Only two levels of headings should be numbered. Lower level headings remain unnumbered; they are formatted as run-in headings.

Sample Heading (Fourth Level) The contribution should contain no more than four levels of headings. Table 1 gives a summary of all heading levels.

Table 1. Table captions should be placed above the tables.

Heading level	Example	Font size and style
Title (centered)	**Lecture Notes**	14 point, bold
1st-level heading	**1 Introduction**	12 point, bold
2nd-level heading	**2.1 Printing Area**	10 point, bold
3rd-level heading	**Run-in Heading in Bold.** Text follows	10 point, bold
4th-level heading	*Lowest Level Heading.* Text follows	10 point, italic

Displayed equations are centered and set on a separate line.

$$x + y = z \tag{1}$$

Please try to avoid rasterized images for line-art diagrams and schemas. Whenever possible, use vector graphics instead (see Fig. 1).

Theorem 1. *This is a sample theorem. The run-in heading is set in bold, while the following text appears in italics. Definitions, lemmas, propositions, and corollaries are styled the same way.*

Fig. 3. A figure caption is always placed below the illustration. Please note that short captions are centered, while long ones are justified by the macro package automatically.

Proof. Proofs, examples, and remarks have the initial word in italics, while the following text appears in normal font.

For citations of references, we prefer the use of square brackets and consecutive numbers. Citations using labels or the author/year convention are also acceptable. The following bibliography provides a sample reference list with entries for journal

References

1. Author, F.: Article title. Journal **2**(5), 99–110 (2016)
2. Author, F., Author, S.: Title of a proceedings paper. In: Editor, F., Editor, S. (eds.) CONFERENCE 2016, LNCS, vol. 9999, pp. 1–13. Springer, Heidelberg (2016). https://doi.org/10.10007/1234567890
3. Author, F., Author, S., Author, T.: Book title. 2nd edn. Publisher, Location (1999)
4. Author, A.-B.: Contribution title. In: 9th International Proceedings on Proceedings, pp. 1–2. Publisher, Location (2010)
5. LNCS Homepage, http://www.springer.com/lncs. Last accessed 4 Oct 2017