Unblock Me

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***Abstract*—The aim of this paper is to implement and compare Artificial Intelligence algorithms for solving the game Unblock Me, in which rectangular pieces block the path of a red special piece. The objective of the game is for the special piece to reach the exit of the level, which is achieved by moving it and the other pieces. The problem will be described and then formulated as a *Search Problem*, together with some discussion on the reasoning behind some of the decisions taken during this process. Several algorithms will be investigated, along with testing them against levels with varying difficulty and branching factors. Both the efficiency in reaching a solution and the cost of the calculated solution will be taken into account in the pursuit for the optimal *Search Algorithm*. NEEDS PART ABOUT SECTION V THAT WILL BE CHANGED**

***Index Terms*—Artificial Intelligence, Search Problems, Path finding algorithms, Graph Algorithms, DFS, BFS, Iterative Deepening, Greedy Search, A*, Bi-directional Search**

I. Introduction

The optimization problem that is the aim of this paper will be approached by employing Constraint Logic Programming (*CLP*), with the use of `SICStus`'s Constraint Logic Programming over Finite Domains (`clpfd`) library.

Firstly, the problem will be described in further detail, and its structure will be formalized as an optimization problem. Secondly, the approach taken will be illustrated with an increased depth, with several subsections for each relevant topic. Thirdly, the manner in which the solution is presented is specified. In addition, an example of a problem instance, its solution and interpretation of its results is portrayed. Finally, a small section covers the conclusions and future work.

Alguns pargrafos motivando e introduzindo o tema e os objetivos do documento e descrevendo a estrutura do artigo.

II. Problem Description

'Unblock Me' is a puzzle game that was released in 17-06-2009 by Kiragames. Each puzzle consist in a 6x6 cells board, surrounded with walls (except for the puzzle's exit).

Fig. 1. Example of an *Unblock Me* level

The game's objective is to move a special piece to the level's exit, by moving that and the other pieces with the least number of movements possible. Pieces are rectangles with a given orientation (vertical or horizontal) and constant length. Pieces can only move in the direction of their orientation into empty cells (they may not overlap).

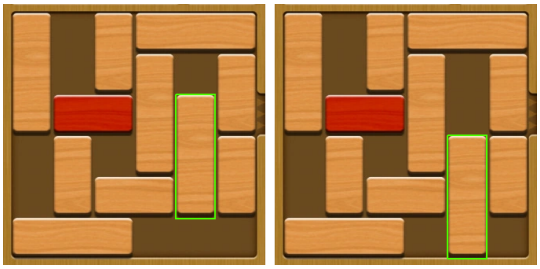

Fig. 2. Piece moving down one cell

Levels are fully surrounded by walls, except for the level's exit door that is alligned with the special piece and by which only the special piece can go through. The level is completed once the piece goes through the exit door.

Fig. 3. Beating a level by going through the exit

Some levels may even contain fixed blocks that can not be moved, representing obstacles.

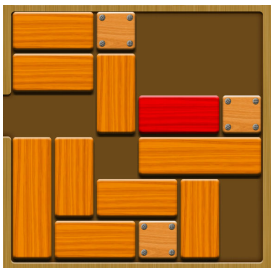

Fig. 4. Example of an *Unblock Me* level containg fixed blocks

III. Problem Formulation

The game's solving process can be formulated as a searching problem, in which the goal is to find the sequence of moves (state transitions) that take the special piece to the level's exit door - the problem's goal state.

A. Game State Representation

- List of pieces, where each piece contains the following information:
  - Origin Square (top left piece corner, e.g. (0,0))
  - Length (e.g. 4)
  - Direction (H or V)
- Reference to the special piece
- Matrix of booleans, where True means the cell is empty

This representation of the game state makes the generation of the valid movements easier, due to the fact that to determine possible movements Esta representao do estado do jogo facilita a gerao de todos os movimentos vlidos, devido ao facto de que o que condiciona o movimento de uma pea no ser necessariamente dependente das outras peas, mas dos espaos vazios do estado atual. Para gerar estes movimentos, basta percorrer a lista de peas, verificando se cada pea possui algum espao vazio em cada uma das suas duas extremidades (com base na sua orientao). A representao apresentada facilita a execuo desta tarefa, tornando-a tambm pouco custosa (facto importante devido ao elevado nmero de clculos deste tipo): Utilizando uma lista para armazenar todas as peas, trivial percorrł-la a fim de determinar quais delas se podem mover num dado estado; Utilizando uma matriz (de valores booleanos, que indicam se uma clula est ou no ocupada) trivial verificar se as duas clulas adjacentes s extremidades de uma pea esto ou no vazias Por fim, a utilizao de uma referłncia para a pea especial permite um acesso constante a essa pea, que ser til para as operaes relacionadas com as heursticas de avaliao.

B. Initial State

The initial state depends of the level in question, being represented by a game state described in subsection III-A.

C. Goal State

The goal state consists of a piece configuration where the special piece reaches the level exit.

D. Operators

- Move piece to the left:
  - Pre-conditions:
    - Piece with horizontal orientation
    - Cell that is adjacent to the piece's left extremity must be empty
  - Results: The pieces position moves one cell to the left
  - Cost: 1 movement
- Move piece to the right:
  - Pre-conditions:
    - Piece with horizontal orientation
    - Cell that is adjacent to the piece's right extremity must be empty
  - Results: The pieces position moves one cell to the right
  - Cost: 1 movement
- Move piece up:
  - Pre-conditions:
    - Piece with vertical orientation
    - Cell that is adjacent to the piece's top extremity must be empty
  - Results: The pieces position moves one cell up
  - Cost: 1 movement
- Move piece down:
  - Pre-conditions:
    - Piece with vertical orientation
    - Cell that is adjacent to the piece's bottom extremity must be empty
  - Results: The pieces position moves one cell down
  - Cost: 1 movement

E. Path cost

The solution's path cost that is to be minimized is equal to the number of movements made (number of state transitions).

IV. Related Work

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V. Conclusions and Development Perspectives

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References

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