Nurikabe, heuristic search, puzzle

Shi-Jim Yen[1], Jr-Chang Chen[2], Tzu-Der Chuang[3], Shih-Yuan Chiu[4]

[1]Department of Computer Science and Information Engineering, National Dong Hwa University, Hualien, Taiwan. sjyen@mail.ndhu.edu.tw
[2]Department of Applied Math, Chung Yuan Christian University, Taoyuan , Taiwan. jccchen@cycu.edu.tw
[3]Department of Computer Science and Information Engineering, National Dong Hwa University, Hualien, Taiwan. m9721011@ems.ndhu.edu.tw
[4]Department of Computer Science and Information Engineering, National Dong Hwa University, Hualien, Taiwan. d9621005@ems.ndhu.edu.tw

Abstract

This paper proposed a heuristic search by mixing pattern matching method to solve Nurikabe puzzle games. First, find the basic rule of puzzle games, and determined part of the region quickly. Then use the advanced detection to answer the part in which basic rule is not able to solve. After heuristic detection, we use Depth-First-Search to solve remain part of question. Authenticating Our method by solving the puzzle problems from internet, confirm that using heuristic search can improve solving speed and efficient.

Keywords: Puzzle Game, Heuristic, Depth-First-Search, Nurikabe

Introduction

Origin:

Nurikabe is a logical puzzle game invented by Nikoli Company. According to Japanese folklore in Kyushu, Nurikabe is a phantom wall which will appear in front of people walking at night, and will block their way. The origin of Nurikabe is uncertain nowadays, but it is used to referring to those who get lost. This logical puzzle game makes use of this folklore to make the rules of the game. The solutions of the game can be obtained by logical analysis and conjectural ability.

Introduction of Nurikabe:

Nurikabe is constructed by grids of M*N. There are three kinds of grids in this game: black grids, white grids, and grids with numbers. The region, connecting a white grid with a grid in which there is a number, is called "island," and the black grids next to the "island " is named "wall," like figure 1.
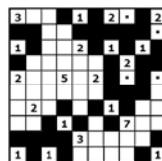

Figure 1.

Every game has partial implication in grids of M*N, and there is only one solution in every game. The goal of this game is to figure out how the wall is formed in the unknown region of grids. Three conditions are needed for the unknown region:

1. There should be only one grid with a number on the "island" formed by white grids and a grid with the number. The amount of the grids should correspond to the implied number in the grid.
2. The walls formed by the black grids in a M*N grid must connect with each other.
3. In the grids of M*N, there shouldn't be four black grids in the form of 2*2.

By following the rules mentioned above, the unknown grids will be solved through logical thinking to figure out the exclusive solution for the game.

Detective algorithm

The algorithm to answer the question has three processes, including "basic detection", "advanced detection" and "Depth First Search."

A. Basic detection

a. In figure 2-1, use walls to isolate the grid formed as an island with 1 in it.

b. In figure 2-2, directly determine the grids, which will connect two grids with numbers, as walls.
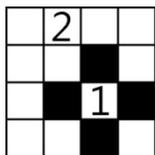
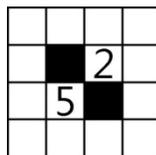Figure 2-1.   Figure 2-2.

B. Advanced detection

a. In figure 3-1, 2, 3, The walls and islands with only one direction to extend should be stretched out directly to be walls and islands.
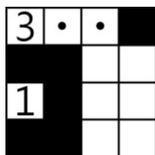
Figure 3-1.   Figure 3-2.   Figure 3-3.

b. In figure 4-1,2, close the island which has enough number of grids.
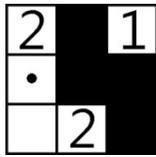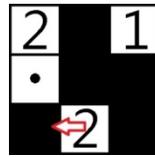
Figure 4-1.   Figure 4-2.

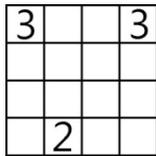c.In figure 5-1,2, the grids, that cannot be reached by islands, will be
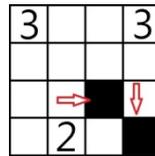   reckoned as walls.

Figure 5-1.   Figure 5-2.

d.In figure 6-1,2, the unknown grid, which is going to be the last one of the four black
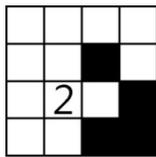grids in the form of 2*2, should be part of other islands, so it must be determined as a
white grid.

Figure 6-1.   Figure 6-2.
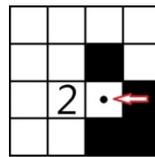
e.In figure 7-1,2, the grids that belong to the island of its number should not connect
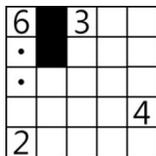together, so we recognize them to be walls.

Figure 7-1.   Figure 7-2.

f.In figure 8-1,2, the grid which is not able to be connected with other islands must be
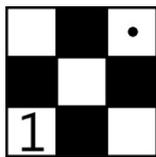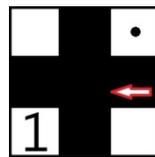walls.

Figure 8-1.   Figure 8-2.

g.In figure 9-1,2, the region, which, no matter how to extend, have to be a part of the island, should be determined as white grids.
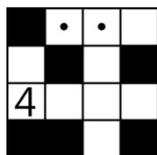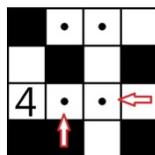

| Figure 9-1. | Figure 9-2. |

C. Depth-First-Search detection

Use DFS method to directly detect the rest grids which are unable to be determined by basic and advanced detection.

Experimental

We obtained 100 25*25-square subjects for this Nurikabe examination from the following website[1]. and result is thus shown in Table 1.

	basic test, advanced test	DFS search
Time(s)	1.0009(s)	6.9259(s)
Percentage(%)	78.94%	21.06%

Table 1.

Conclusion

Heuristics, like the basic test and the advanced test, can answer questions very fast, and can answer most of the unknown grids. The total time the algorithm takes to answer the questions is 7.9268(s) in average. The data in Form 1 shows that simply using DFS to answer the questions is not able to achieve the speed above. Therefore, using heuristics to answer the questions first and having DFS to deal with the rest of the questions can improve the speed of finishing solving the game.

Reference

[1] Nurikabe - online puzzle game, http://www.puzzle-nurikabe.com/.