Number Solitaire Game HyperSpaceWorm

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Abstract: This paper proposes a hyperspace puzzle game, and writes a problem-solving program. Because this game process is similar to worms occupying a hyperspace, it is named HyperSpaceWorm (***M***, ***N***, ***P***). The space of this game is ***M***-dimensional, the size of each dimension is ***N***, and the ***P*** value determines the length and number of the number sequence to be completed. The purpose of the game is to fill up the entire multi-dimensional space with these worm-like numerical sequences in sequence. We can adjust ***M***, ***N***, and ***P*** to change the difficulty of the game and create levels to make the game more interesting. This game process can train the concept of hyperspace and spatial thinking ability, and can also set up a large number of levels with different difficulties, which has considerable potential.

Keywords: Hyperspace search, puzzle game, searching algorithm

1. Introduction

Solitaire is a public puzzle game, including words, numbers, idioms, cards, etc., which can form a Solitaire game. Green Culture published a book on the Numberdragon game in 2007[1], which involves connecting 9 groups of numbers in a 9×9 grid. For example, Figure 1 is question 11 in the book [1]. The picture on the left is a 9 times 9 question, and the picture on the right is the answer. This puzzle game is quite fun and can exercise your mind, but there is not much variety and the difficulty level of the game is not easy to adjust.

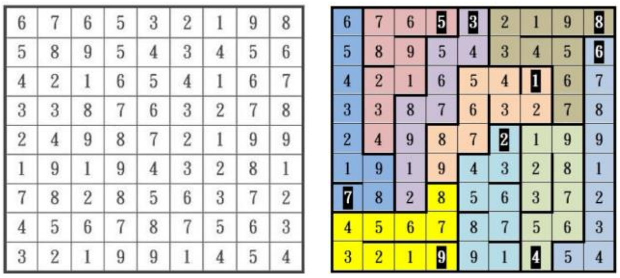

Fig. 1. Numberdragon problem no. 11. [1]

This paper redesigns the digital Solitaire game to add variety and adjust the difficulty of the game. We can define Numberdragon as a game with a 2-dimensional space and the scale of each dimension is 9. Based on this definition, the intuitive idea is that by adjusting the dimensions and scale as variables, the difficulty of the game can be adjusted.

The research of puzzle games includes game definition, difficulty and complexity design [2], question generator [3], problem solver to solve the questions [4], estimation and testing of player behavior [5], etc., and in recent years, information security has received increasing attention, and data hiding in puzzle games has also become an important issue [6][7][8]. In general, the questions in puzzle games hope to have the only solution [9], so that they can compare the answers in books.

This paper defines this puzzle game and provides some examples. Then design a tree search problem-solving program and discuss how to use heuristic to reduce the number of tree nodes that need to be generated.

2. Game definition

This paper names this game HyperSpaceWorm, which means there are many worm sequences in HyperSpace.

Definition 1: Definition of HyperSpaceWorm (M, N, P)

HyperSpaceWorm(***M***, ***N***, ***P***) is a puzzle game, where ***M***, ***N***, ***P*** are positive integers and ***P*** <= ***M***. This game is played in an ***M***-dimensional space with a spatial scale of ***N***. There is a positive integer number in each square in the space, and the maximum number of this number is N^P. The game space is filled with digital Solitaire sequences. The number of sequences is N^{M-P}. The length of each sequence is N^P. The sequence contents are 1, 2, 3,... , N^P at the beginning, and the corresponding increments to the end are N^P, N^P -1, N^P -2, …,1, this game requires finding these numerical Solitaire sequences in this hyperspace, and the direction of Solitaire is adjacent squares.

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Definition 2: Definition of adjacent squares

If the difference in index value (index) in a certain dimension between two squares in the multidimensional space is 1, the two squares are considered to be adjacent. For example, in a 3-dimensional space, (2, 3, 5) and (2, 4, 5) are adjacent.

The space defined by this HyperSpaceWorm is symmetrical, and the scales are all *N*. It can also try to use different sizes for each dimension, but it is too complicated and not suitable for a game. The length of the sequence can be *N* in low dimensions, but as the dimension increases, this length will be too short compared to the entire space, so the length of the digital solitaire sequence we define is also a variable. According to our definition, the dragon counting game in Figure 1 is HyperSpaceWorm (2, 9, 1). Below we use two examples to illustrate this definition.

Example 1: HyperSpaceWorm (2, 4, 1)

Figure 2 can be defined as a HyperSpaceWorm problem with M = 2, N = 4, and P = 1. The goal is to find the four-number Solitaire sequence of 1234, 2341, 3412, 4123. The figure on the left is the question, and the right is the answer. The numbers at the beginning of the sequence are marked with an underline.

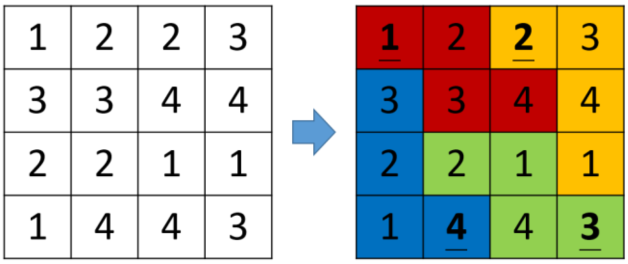

Fig. 2. HyperSpaceWorm(2, 4, 1) problem and answer.

Example 2: HyperSpaceWorm (3, 4, 1)

Figure 3 is HyperSpaceWorm (3, 4, 1). The goal is to find four groups of 1234, 2341, 3412, 4123 digit sequences, a total of 16 sequences. On the left, we draw this topic in a 3D perspective figure. Although it looks very complicated, when actually playing the game, we can play the game by rotating the cube on your mobile phone. The figure on the right spreads the third dimension into four 2-dimensional spaces, and then uses double arrows to represent the relationship between the four 2-dimensional spaces. In this way, the game can be played on the 2-dimensional plane to represent the 3-dimensional space. The right is the answer. In theory, this technique of spreading dimensions can continuously spread out all super-dimensional hyperspaces.

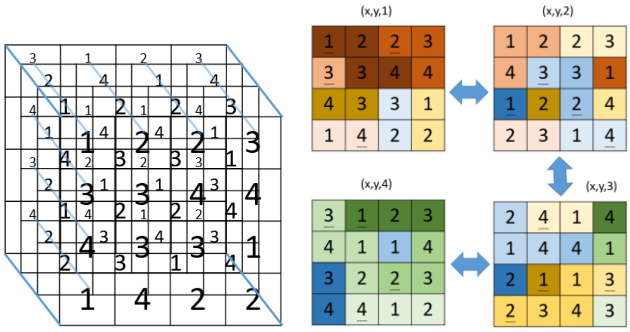

Fig. 3. HyperSpaceWorm (3, 4, 1) problem and answer.

3. Experiments and results

We develop a program and calculated the results of the problem in Figure 1 as shown in Figure 4. A total of 520,140,091 squares were searched without using any heuristic methods. However, dead ends are checked to generate backtracking. In addition, in order to use a text interface to express the answer, we created a representation method, numbering each sequence as a, b, c, ... as in the left of figure 4.

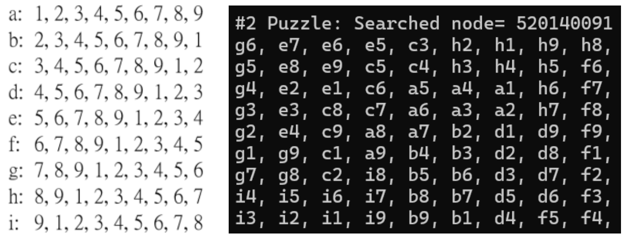

Fig. 4. The searching result of the problem in figure 1.

Since when the number of a certain square is equal to the number at the beginning of the sequence and this square has no entrance, we can know that this square must be the beginning of the sequence. It can first determine a total of 10 beginnings and ends, and then check the unique paths from the beginning and the end respectively. It can confirm the value of 47 squares. At this time, there are only 34 squares left to be searched, and the final number of searches required is 2,629,901 as in Figure 5. It can be seen that adding heuristic knowledge can significantly reduce the number of searches.

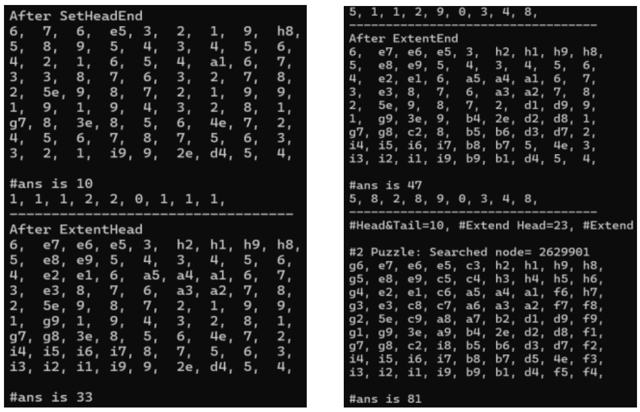

Fig. 5. Use heuristic to solve the problem in figure 1.

4. Conclusion

This paper proposes a HyperSpaceWorm (M, N, P) multi-dimensional space digital solitaire game. The space of this game is M-dimensional, the size of each dimension is N, and NM-P number sequences need to be completed. We can adjust M, N, and P to change the difficulty of the game and make this game more interesting. This paper proposes the definition of this puzzle game and the problem-solving program and Heuristic. In the future, we can continue to conduct complexity analysis, problem-solving methods, generate questions, prove whether there is a unique solution, and discuss the possibility of information security applications.

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