

Dla cofania o 100 ruchów:

Średnia z 30 losowych stanów gry, używając heurystyki

```
int heuristic(vector<vector<int>> &gamestate)
{
    int grade = 0;

    for(int i = 0; i<4; i++)
    {
        for(int j=0; j<4; j++)
        {
            if(gamestate[i][j]==0) continue;
            grade = grade + (abs(i-(gamestate[i][j]-1)/4)) + (abs(j-(gamestate[i][j]-1)%4));
        }
    }

    return grade;
}
```

I zwiększając g(n) na każdym poziomie o 1

```
5 3 8 7
9 1 6 12
10 2 15 11
13 14 4 0
34 moves: LURDLURUULLDDLURDRRULDDDRUULURDDD
156506 visited states

10 9 5 7
3 1 4 2
14 12 8 15
6 13 11 0
36 moves: ULLLDURUULURRDRULDLDLURDDLURRRDRDLDR
833 visited states

1 2 3 4
10 5 11 6
14 9 13 8
7 12 15 0
28 moves: LUULDDRULLDRULURRRDLLURRDDR
4186 visited states

2 5 6 8
1 10 4 12
9 7 3 15
13 14 11 0
24 moves: UUULDDRUULDRDLLUULDRRDDR
2103 visited states

1 14 4 10
12 2 6 3
```

9 5 15 7
13 8 11 0
42 moves: LUUURDLLURDDDLLURULDDR UUURRDDLD RULLURRDLDR
432216 visited states

1 2 3 4
14 5 7 10
9 6 11 8
13 15 12 0
20 moves: LLLUURRRDLULDLDRURRD
540 visited states

2 1 3 8
6 7 4 11
5 9 10 15
13 12 14 0
34 moves: LLULUURRDLLDRRDRULLDRRUULLDLDRRRD
377381 visited states

1 7 3 4
14 11 15 13
10 5 8 2
9 6 12 0
44 moves: UULDRDLURULLDLURDRRULLDDR UUURULLDDLDRURUURDDD
2733411 visited states

1 2 3 4
5 10 7 12
9 11 8 15
13 6 14 0
18 moves: UULLDDRRULULDRURDD
1230 visited states

3 9 4 8
1 7 6 11
5 14 2 12
10 13 15 0
30 moves: UUULDLULDDDRURUULLDRDLUURDRDRD
9854 visited states

9 5 2 3
10 6 8 7
12 1 4 15
13 14 11 0
26 moves: ULULDLUURDRRD LLLUURRRDDLDR
433 visited states

3 6 7 4
2 5 8 14
1 10 11 12
9 13 15 0

26 moves: UULDRDLULUULDDRRUULLDDDRRR

2661 visited states

2 3 4 11

1 5 12 7

10 14 8 15

9 6 13 0

26 moves: ULLDRUURULDRDLUULLDRDLDRRR

622 visited states

1 7 2 4

6 10 3 8

5 13 12 15

9 14 11 0

16 moves: ULDLUUURDLLDDRRR

80 visited states

6 3 4 12

5 1 8 9

13 7 2 15

14 11 10 0

28 moves: UUULLDDRRULLDRDLLUUURDLDRRDR

704 visited states

1 3 8 7

2 6 11 4

10 15 14 12

9 5 13 0

32 moves: ULLULDRDRURDLUUURDLULDDLURDLDRRR

35516 visited states

5 1 7 2

3 8 4 12

13 14 9 15

11 6 10 0

32 moves: UULLLDRDLUUURRRDLLURDLDRDLLURRDR

3247 visited states

9 1 8 2

6 3 4 12

10 5 7 15

11 13 14 0

28 moves: UULURDLLDLDRULUURRDDLLURDDR

695 visited states

6 1 4 8

2 12 15 3

5 7 11 9

13 10 14 0

30 moves: LURULLDRRULDDRUUULDLLURDLDRDRR

4353 visited states

1 3 2 11
7 8 15 9
6 5 4 12
13 10 14 0
34 moves: ULURDLULURDRULDLLDRRRUULDLLDRDRURD
24084 visited states

6 10 3 4
1 2 7 8
5 13 9 12
14 11 15 0
28 moves: LLLUURULDDRRDLULDRUUULDDDRRR
21766 visited states

9 7 4 8
5 2 3 6
1 10 11 12
13 14 15 0
32 moves: ULURULLDLURRDDLULDRUURDLULDDRRRD
148389 visited states

6 10 4 3
7 1 8 11
2 5 12 15
13 14 9 0
34 moves: ULDRUULULDLDRRRULURDDLULLURDLDRRRD
30439 visited states

5 1 4 7
10 11 8 12
3 2 13 15
9 14 6 0
32 moves: UULLDRDLULUURDDRULDLDRRRUUULDRDD
9147 visited states

5 4 8 3
1 12 6 15
14 2 9 11
13 10 7 0
42 moves: UULLLDRRURULLDLDRRDLUULURDRRULDDDLURDRULDR
1323192 visited states

5 1 3 4
9 7 6 8
10 11 2 12
13 14 15 0
20 moves: UULDLURRDLLLLUURDRDRD
1003 visited states

1 8 7 2

```

13 14 3 6
5 11 10 4
9 15 12 0
38 moves: LULULDRURURDDLULULDRURDLULDRDDLULDRURRD
137216 visited states

1 4 12 5
9 3 11 8
13 2 7 15
10 6 14 0
30 moves: ULUURDLULDDRRUULLDRDLDLUURDDRR
1187 visited states

1 6 2 4
9 5 12 3
13 10 11 7
14 8 15 0
24 moves: LUURDLDLLUURURDDDRULURDD
1352 visited states

1 2 3 4
5 10 7 8
9 11 6 12
13 14 15 0
10 moves: UULDLURRDD
94 visited states

Average moves: 29
Average visited states: 182148

```

Dla cofania o 100 ruchów:

Średnia z 50 losowych stanów gry, używając heurystyki

```

int heuristic(vector<vector<int>> > gamestate)
{
    int grade = 0;

    for(int i = 0; i<4; i++)
    {
        for(int j=0; j<4; j++)
        {
            if(gamestate[i][j]==0) continue;
            if(gamestate[i][j] != i*4+j+1) grade++;
        }
    }

    return grade;
}

```

I zwiększając $g(n)$ na każdym poziomie o 1

1 6 2 4
5 9 10 7
13 3 8 12
14 15 11 0
18 moves: ULLURDDLURUURDRDD
1366 visited states

6 3 4 8
2 9 7 12
1 5 10 15
13 14 11 0
18 moves: UUULLLDDRUULDDRDRDR
643 visited states

5 1 3 11
2 4 12 8
9 7 6 15
13 10 14 0
26 moves: UULLLURRDRULLDDRURDLULDDR
141692 visited states

1 2 6 4
5 9 3 8
13 10 7 11
14 15 12 0
20 moves: LLLUUURRDDLUULDDRDRD
8519 visited states

1 2 4 8
5 6 3 11
9 10 7 12
13 14 15 0
8 moves: UUULDDRDRD
26 visited states

1 3 7 4
6 2 8 11
5 9 15 12
13 10 14 0
14 moves: UULULDLDRDRURD
103 visited states

2 5 3 4
9 11 7 8
6 1 10 12
13 14 15 0
18 moves: UULLDLURULDRDRURDD
2398 visited states

6 7 4 8
2 3 1 12
5 10 11 15
9 13 14 0
20 moves: UUULLDRULDLURDLDDRRR
1084 visited states

5 1 2 3
10 9 8 6
15 14 4 12
11 13 7 0
30 moves: ULLDRURURDLDLULURRDLUURRRDDD
772529 visited states

1 7 3 15
5 2 6 11
9 10 4 8
13 14 12 0
22 moves: UUULLDRRDLURDDL UURDDD
20654 visited states

2 4 7 3
1 10 6 8
5 9 12 15
13 14 11 0
20 moves: UUULLDDRURRULDRDLDR
3503 visited states

10 1 2 4
9 11 3 8
5 6 14 12
13 7 15 0
24 moves: LULULURRDDLULDRDRULURDDR
66477 visited states

2 7 6 4
10 11 3 8
1 12 15 14
5 9 13 0
26 moves: ULLULDDRURULLUURDLULDDRRR
72942 visited states

5 7 1 3
6 12 11 4
9 2 14 8
13 10 15 0
24 moves: LUULDRULURDLLURRRDDLDRR
35335 visited states

5 2 8 7

6 1 11 4
9 3 12 15
13 10 14 0
24 moves: ULUURDLULDDRULLURRDDLDRR
35792 visited states

1 2 3 4
5 6 7 8
14 15 13 11
9 10 12 0
14 moves: LULDRULLDRURRD
366 visited states

5 6 3 4
1 2 7 8
10 15 11 12
9 13 14 0
22 moves: ULLULURDDLURDLDDRURD
16511 visited states

1 5 4 7
6 2 3 12
9 8 10 15
13 14 11 0
30 moves: UUULLDLURRDRDLLURDRULLULDRDRDR
2154832 visited states

1 2 4 8
5 6 3 12
10 7 15 11
9 13 14 0
16 moves: ULLLDRRRUUULDDDR
395 visited states

1 3 4 7
5 2 15 8
9 6 10 11
13 14 12 0
16 moves: UUULLDDRURDDLURD
864 visited states

2 3 7 4
1 6 12 15
13 10 8 14
5 9 11 0
24 moves: UULDLLDRURDRUULULLDDDRRR
24706 visited states

1 3 4 7
5 2 6 8
9 12 15 11

13 10 14 0
18 moves: UUULLDRRDLLDRRULDR
2387 visited states

5 1 2 3
7 9 15 4
6 14 8 11
13 12 10 0
24 moves: ULDLUULDRRULLURRRDDDLURD
21718 visited states

5 1 7 3
10 6 4 8
2 9 15 12
13 11 14 0
22 moves: UULLLDRDRULULURDRURDDD
8991 visited states

1 2 8 3
5 7 10 4
11 15 14 12
9 13 6 0
26 moves: ULLLDRRURDLULDRUUURDLLDRDR
192074 visited states

1 6 4 11
5 10 3 2
14 15 13 7
9 8 12 0
28 moves: LULDRULLDRUURRULDLURDDRULDRD
333910 visited states

1 2 3 4
5 6 8 12
13 11 7 15
10 9 14 0
12 moves: UULDLDLURDRR
96 visited states

1 2 3 4
5 6 7 8
13 12 11 14
10 9 15 0
18 moves: ULDRULLDLURDRRULDR
4095 visited states

1 2 3 4
5 6 8 12
9 10 11 7
13 14 15 0
8 moves: LURULDDR

73 visited states

6 3 7 4

2 1 8 12

5 10 11 15

9 13 14 0

16 moves: U U L U L D L U R D L D D R R R

141 visited states

Average moves: 20

Average visited states: 130807