To test my Sudoku solver program I searched for a few easy and hard puzzles online. `sudoku.com` offered easy, medium, hard, and expert level puzzles so I tested one of each. Here are the results...

```
karl@asimov:~/cs310/a423$ ./sudoku < gameEasy.txt
        0   1   2   3   4   5   6   7   8
    ++===+===+===++===+===+===++===+===+===++
  0 || 6 | 9 |   || 1 | 7 |   ||   |   |   ||
    ++---+---+---++---+---+---++---+---+---++
  1 || 3 | 5 |   ||   | 4 |   || 1 |   |   ||
    ++---+---+---++---+---+---++---+---+---++
  2 || 8 |   | 2 || 3 | 6 |   || 7 |   | 4 ||
    ++===+===+===++===+===+===++===+===+===++
  3 ||   |   |   ||   |   |   || 9 |   | 8 ||
    ++---+---+---++---+---+---++---+---+---++
  4 || 9 | 4 |   ||   |   |   ||   |   | 5 ||
    ++---+---+---++---+---+---++---+---+---++
  5 ||   |   |   || 5 | 9 |   || 6 | 3 |   ||
    ++===+===+===++===+===+===++===+===+===++
  6 || 2 | 6 |   ||   | 5 |   ||   | 8 | 7 ||
    ++---+---+---++---+---+---++---+---+---++
  7 ||   | 8 | 1 ||   |   | 6 || 4 | 9 |   ||
    ++---+---+---++---+---+---++---+---+---++
  8 ||   | 7 | 3 ||   | 8 | 2 ||   | 1 |   ||
    ++===+===+===++===+===+===++===+===+===++

        0   1   2   3   4   5   6   7   8
    ++===+===+===++===+===+===++===+===+===++
  0 || 6 | 9 | 4 || 1 | 7 | 5 || 8 | 2 | 3 ||
    ++---+---+---++---+---+---++---+---+---++
  1 || 3 | 5 | 7 || 2 | 4 | 8 || 1 | 6 | 9 ||
    ++---+---+---++---+---+---++---+---+---++
  2 || 8 | 1 | 2 || 3 | 6 | 9 || 7 | 5 | 4 ||
    ++===+===+===++===+===+===++===+===+===++
  3 || 1 | 3 | 5 || 6 | 2 | 7 || 9 | 4 | 8 ||
    ++---+---+---++---+---+---++---+---+---++
  4 || 9 | 4 | 6 || 8 | 1 | 3 || 2 | 7 | 5 ||
    ++---+---+---++---+---+---++---+---+---++
  5 || 7 | 2 | 8 || 5 | 9 | 4 || 6 | 3 | 1 ||
    ++===+===+===++===+===+===++===+===+===++
  6 || 2 | 6 | 9 || 4 | 5 | 1 || 3 | 8 | 7 ||
    ++---+---+---++---+---+---++---+---+---++
  7 || 5 | 8 | 1 || 7 | 3 | 6 || 4 | 9 | 2 ||
    ++---+---+---++---+---+---++---+---+---++
  8 || 4 | 7 | 3 || 9 | 8 | 2 || 5 | 1 | 6 ||
    ++===+===+===++===+===+===++===+===+===++

Input size: 43
Elaborated: 204
Dead ends: 156
karl@asimov:~/cs310/a423$
```

```
karl@asimov:~/cs310/a423$ ./sudoku < gameMedium.txt
       0   1   2   3   4   5   6   7   8
    ++===+===+===++===+===+===++===+===+===++
  0 || 6 |   |   || 5 |   |   || 9 |   |   ||
    ++---+---+---++---+---+---++---+---+---++
  1 || 8 |   | 1 || 6 |   | 4 || 2 | 7 |   ||
    ++---+---+---++---+---+---++---+---+---++
  2 ||   |   |   ||   | 7 | 2 || 6 |   |   ||
    ++===+===+===++===+===+===++===+===+===++
  3 ||   |   |   ||   | 8 | 1 || 7 |   | 4 ||
    ++---+---+---++---+---+---++---+---+---++
  4 ||   |   | 4 ||   | 3 |   || 1 |   |   ||
    ++---+---+---++---+---+---++---+---+---++
  5 ||   | 5 |   ||   |   | 9 ||   | 2 | 3 ||
    ++===+===+===++===+===+===++===+===+===++
  6 ||   |   |   ||   |   | 6 ||   |   |   ||
    ++---+---+---++---+---+---++---+---+---++
  7 ||   | 6 |   ||   |   |   || 4 |   |   ||
    ++---+---+---++---+---+---++---+---+---++
  8 ||   |   |   || 3 | 4 |   || 5 |   | 6 ||
    ++===+===+===++===+===+===++===+===+===++

       0   1   2   3   4   5   6   7   8
    ++===+===+===++===+===+===++===+===+===++
  0 || 6 | 7 | 2 || 5 | 1 | 3 || 9 | 4 | 8 ||
    ++---+---+---++---+---+---++---+---+---++
  1 || 8 | 3 | 1 || 6 | 9 | 4 || 2 | 7 | 5 ||
    ++---+---+---++---+---+---++---+---+---++
  2 || 5 | 4 | 9 || 8 | 7 | 2 || 6 | 3 | 1 ||
    ++===+===+===++===+===+===++===+===+===++
  3 || 3 | 9 | 6 || 2 | 8 | 1 || 7 | 5 | 4 ||
    ++---+---+---++---+---+---++---+---+---++
  4 || 2 | 8 | 4 || 7 | 3 | 5 || 1 | 6 | 9 ||
    ++---+---+---++---+---+---++---+---+---++
  5 || 1 | 5 | 7 || 4 | 6 | 9 || 8 | 2 | 3 ||
    ++===+===+===++===+===+===++===+===+===++
  6 || 4 | 1 | 5 || 9 | 2 | 6 || 3 | 8 | 7 ||
    ++---+---+---++---+---+---++---+---+---++
  7 || 7 | 6 | 3 || 1 | 5 | 8 || 4 | 9 | 2 ||
    ++---+---+---++---+---+---++---+---+---++
  8 || 9 | 2 | 8 || 3 | 4 | 7 || 5 | 1 | 6 ||
    ++===+===+===++===+===+===++===+===+===++

Input size: 51
Elaborated: 261
Dead ends: 202
karl@asimov:~/cs310/a423$
```

```
karl@asimov:~/cs310/a423$ ./sudoku < gameHard.txt
         0   1   2   3   4   5   6   7   8
      ++===+===+===++===+===+===++===+===+===++
    0 || 9 | 4 | 6 || 1 | 5 |   ||   |   |   ||
      ++---+---+---++---+---+---++-.-+---+---++
    1 || 5 |   | 3 ||   | 8 |   || 7 |   |   ||
      ++---+---+---++---+---+---++---+---+---++
    2 ||   |   |   ||   |   |   ||   |   |   ||
      ++===+===+===++===+===+===++===+===+===++
    3 ||   |   | 4 || 9 | 2 |   ||   |   |   ||
      ++---+---+---++---+---+---++---+---+---++
    4 ||   | 1 |   ||   |   |   ||   |   |   ||
      ++---+---+---++---+---+---++---+---+---++
    5 ||   |   |   ||   |   |   ||   | 7 | 8 ||
      ++===+===+===++===+===+===++===+===+===++
    6 ||   | 8 |   ||   | 4 |   || 6 | 1 |   ||
      ++---+---+---++---+---+---++---+---+---++
    7 ||   |   |   ||   |   |   ||   | 5 | 7 ||
      ++---+---+---++---+---+---++---+---+---++
    8 || 3 |   | 1 || 6 |   |   ||   |   |   ||
      ++===+===+===++===+===+===++===+===+===++


         0   1   2   3   4   5   6   7   8
      ++===+===+===++===+===+===++===+===+===++
    0 || 9 | 4 | 6 || 1 | 5 | 7 || 2 | 8 | 3 ||
      ++---+---+---++---+---+---++---+---+---++
    1 || 5 | 2 | 3 || 4 | 8 | 6 || 7 | 9 | 1 ||
      ++---+---+---++---+---+---++---+---+---++
    2 || 1 | 7 | 8 || 2 | 9 | 3 || 5 | 4 | 6 ||
      ++===+===+===++===+===+===++===+===+===++
    3 || 7 | 3 | 4 || 9 | 2 | 8 || 1 | 6 | 5 ||
      ++---+---+---++---+---+---++---+---+---++
    4 || 8 | 1 | 5 || 7 | 6 | 4 || 9 | 3 | 2 ||
      ++---+---+---++---+---+---++---+---+---++
    5 || 6 | 9 | 2 || 5 | 3 | 1 || 4 | 7 | 8 ||
      ++===+===+===++===+===+===++===+===+===++
    6 || 2 | 8 | 7 || 3 | 4 | 5 || 6 | 1 | 9 ||
      ++---+---+---++---+---+---++---+---+---++
    7 || 4 | 6 | 9 || 8 | 1 | 2 || 3 | 5 | 7 ||
      ++---+---+---++---+---+---++---+---+---++
    8 || 3 | 5 | 1 || 6 | 7 | 9 || 8 | 2 | 4 ||
      ++===+===+===++===+===+===++===+===+===++

Input size: 57
Elaborated: 285
Dead ends: 210
karl@asimov:~/cs310/a423$
```

```
karl@asimov:~/cs310/a423$ ./sudoku < gameExpert.txt
        0   1   2   3   4   5   6   7   8
    ++===+===+===++===+===+===++===+===+===++
  0 || 2 |   |   ||   |   |   ||   |   |   ||
    ++---+---+---++---+---+---++---+---+---++
  1 || 1 |   | 7 || 4 |   |   ||   |   | 3 ||
    ++---+---+---++---+---+---++---+---+---++
  2 || 3 |   |   || 2 |   |   ||   | 5 |   ||
    ++===+===+===++===+===+===++===+===+===++
  3 ||   |   | 5 ||   | 2 |   ||   |   |   ||
    ++---+---+---++---+---+---++---+---+---++
  4 ||   | 6 |   || 1 |   |   || 4 |   |   ||
    ++---+---+---++---+---+---++---+---+---++
  5 ||   |   |   ||   |   | 7 ||   |   |   ||
    ++===+===+===++===+===+===++===+===+===++
  6 ||   |   |   ||   |   | 3 ||   |   | 6 ||
    ++---+---+---++---+---+---++---+---+---++
  7 || 8 |   |   || 6 |   |   || 2 |   |   ||
    ++---+---+---++---+---+---++---+---+---++
  8 ||   | 4 |   || 8 |   |   ||   | 3 |   ||
    ++===+===+===++===+===+===++===+===+===++

        0   1   2   3   4   5   6   7   8
    ++===+===+===++===+===+===++===+===+===++
  0 || 2 | 5 | 4 || 3 | 6 | 1 || 9 | 7 | 8 ||
    ++---+---+---++---+---+---++---+---+---++
  1 || 1 | 9 | 7 || 4 | 8 | 5 || 6 | 2 | 3 ||
    ++---+---+---++---+---+---++---+---+---++
  2 || 3 | 8 | 6 || 2 | 7 | 9 || 1 | 5 | 4 ||
    ++===+===+===++===+===+===++===+===+===++
  3 || 4 | 3 | 5 || 9 | 2 | 6 || 7 | 8 | 1 ||
    ++---+---+---++---+---+---++---+---+---++
  4 || 7 | 6 | 2 || 1 | 3 | 8 || 4 | 9 | 5 ||
    ++---+---+---++---+---+---++---+---+---++
  5 || 9 | 1 | 8 || 5 | 4 | 7 || 3 | 6 | 2 ||
    ++===+===+===++===+===+===++===+===+===++
  6 || 5 | 2 | 1 || 7 | 9 | 3 || 8 | 4 | 6 ||
    ++---+---+---++---+---+---++---+---+---++
  7 || 8 | 7 | 3 || 6 | 5 | 4 || 2 | 1 | 9 ||
    ++---+---+---++---+---+---++---+---+---++
  8 || 6 | 4 | 9 || 8 | 1 | 2 || 5 | 3 | 7 ||
    ++===+===+===++===+===+===++===+===+===++

Input size: 59
Elaborated: 313
Dead ends: 246
karl@asimov:~/cs310/a423$
```

Through this testing you can see that puzzles meant to be harder for humans are also hard for my Sudoku solver. The easy puzzle only took 204 elaborated nodes while the expert took 313. The easy puzzle had 156 dead ends while the expert puzzle had 246. The medium and hard puzzles we somewhere in between.

It's hard to tell how hard a sudoku will be to solve before you start working it, but the largest indicator seems to be how many cells are filled in to start. The expert puzzle had 22 filled in to start while the easy one had

37. This would make sense as an input size if we were to analyze this program fully. However, it maybe better represented as the number of empty cells to start – this would give us the common correlation of basic operations increasing with input size.

This would mean that the hardest puzzle to solve would be an empty grid. This is the hardest puzzle for my program to solve that I found with my testing with 405 elaborated nodes and 303 dead ends.