Analysis of Random Orderings for Brute Force Alg for 10 Sudoku Puzzles

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Check for packages:

Read Data:

```
rand_10_100 <- read_csv(here("data", "rand_sample_10_1000.csv"))

processed_rand_10_100 <- rand_10_100 |>
  filter(is_solved == TRUE)

glimpse(processed_rand_10_100)
```

```
Rows: 10,000
Columns: 12
$ puzzle_id           <dbl> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,~
$ puzzle              <chr> "1..5.37..6.3..8.9......98...1.......8761.........~
$ clues               <dbl> 27, 27, 27, 27, 27, 27, 27, 27, 27, 27, 27, 27, 27~
$ difficulty          <dbl> 2.2, 2.2, 2.2, 2.2, 2.2, 2.2, 2.2, 2.2, 2.2, 2.2, ~
$ run_id              <dbl> 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, ~
$ solutions_found     <dbl> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,~
$ nodes_explored      <dbl> 1310, 33462, 976292, 23306, 2115, 16571, 35816, 61~
$ max_recursion_depth <dbl> 53, 53, 53, 53, 53, 53, 53, 53, 53, 53, 53, 53, 53~
$ solve_time_ms       <dbl> 0, 4, 127, 3, 0, 2, 4, 0, 27, 210, 6, 4, 10, 44, 3~
$ is_solved           <lgl> TRUE, TRUE, TRUE, TRUE, TRUE, TRUE, TRUE, TRUE, TR~
$ leaves              <dbl> 390, 10830, 326622, 7391, 632, 5332, 9126, 155, 60~
$ backtracks          <dbl> 1256, 33408, 976238, 23252, 2061, 16517, 35762, 56~
```

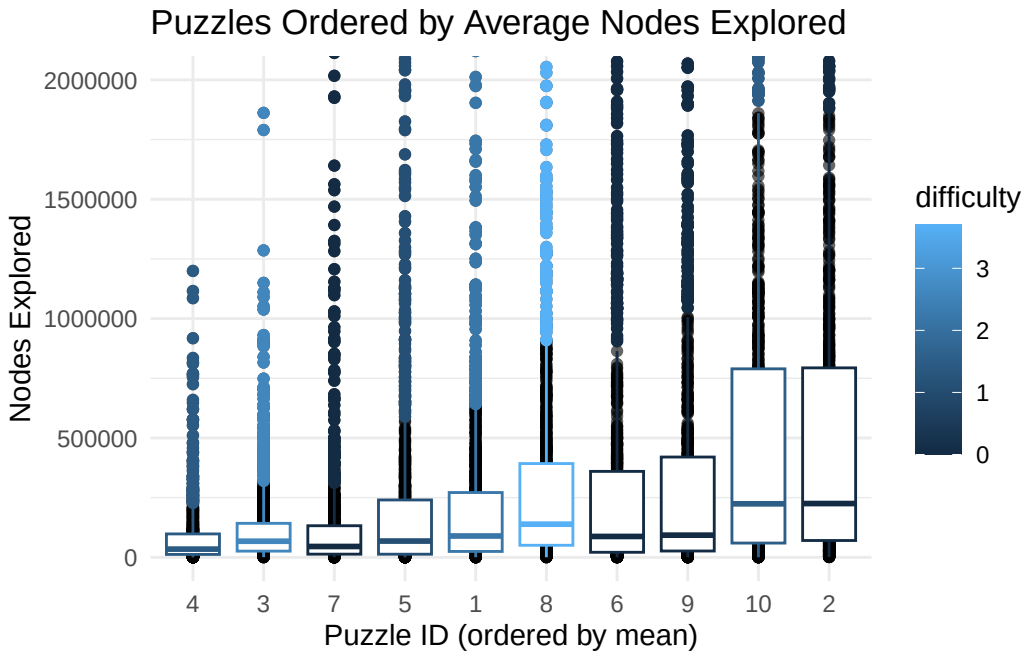
```r
summary_stats <- processed_rand_10_100 |>
  group_by(puzzle_id) |>
  summarise(
    mean_nodes = mean(nodes_explored),
    median_nodes = median(nodes_explored),
    sd_nodes = sd(nodes_explored),
    min_nodes = min(nodes_explored),
    max_nodes = max(nodes_explored),
    difficulty = mean(difficulty),
  ) |>
  arrange(mean_nodes)

summary_stats
```

```
# A tibble: 10 x 7
   puzzle_id mean_nodes median_nodes sd_nodes min_nodes max_nodes difficulty
       <dbl>      <dbl>        <dbl>    <dbl>     <dbl>     <dbl>      <dbl>
 1         4     85475.       34412.  154958.       135   2582152        1.4
 2         3    126201.       67416.  181675.       408   1861811        2.6
 3         7    142255.       45490.  328673.        66   3953269        0
 4         5    222399.       68066.  402425.       114   3306088        1.1
 5         1    297075.       89288.  685826.       150   9592845        2.2
 6         8    333465.      138840.  533937.       268   5752925        3.7
 7         6    507361.       87464. 1187861.       449  12799177        0
 8         9    683555.       92756. 2324342.        81  38847691        0
 9        10    689413.      224174. 1162391.       282  11473428        1.5
10         2    863406.      225328. 1938290.      1387  24943389        0
```

```r
# min nodes tells us something about a human's ability to scan and solve a puzzle
# higher values of min nodes are more correlated with difficulty than the lower values of mi
```

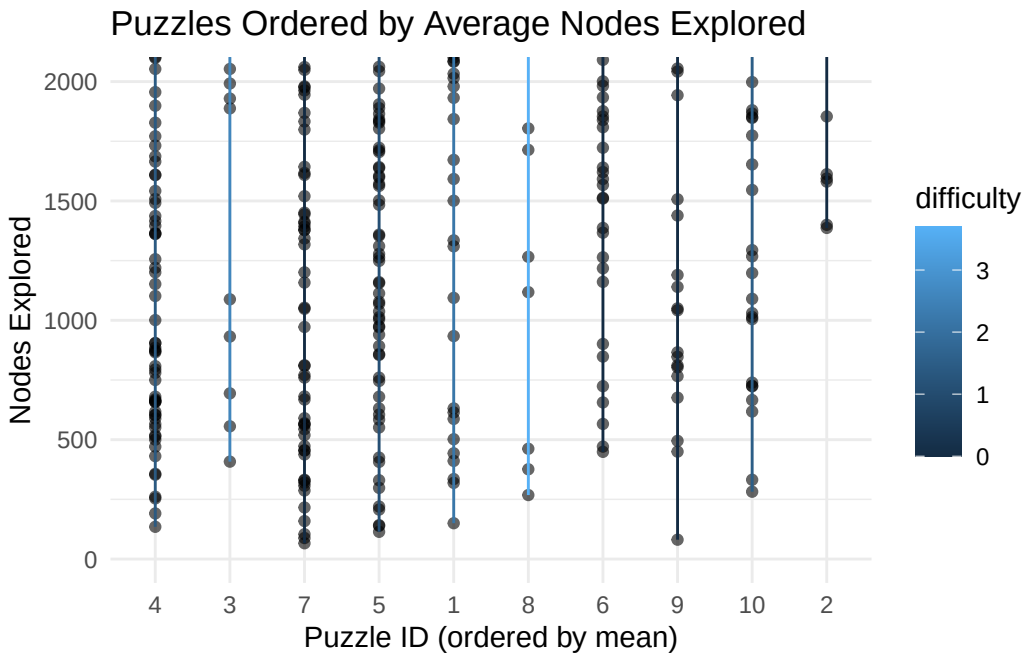
```r
processed_rand_10_100 <- processed_rand_10_100 |>
  mutate(puzzle_id = fct_reorder(factor(puzzle_id), nodes_explored, .fun = mean))

processed_rand_10_100 |>
  ggplot(aes(x = puzzle_id, y = nodes_explored)) +
  geom_point(alpha = 0.6) +
  geom_boxplot(aes(color = difficulty)) +
  coord_cartesian(ylim = c(0, 2000000)) +
  labs(
    title = "Puzzles Ordered by Average Nodes Explored",
```

```
    x = "Puzzle ID (ordered by mean)",
    y = "Nodes Explored"
  ) +
  theme_minimal()
```

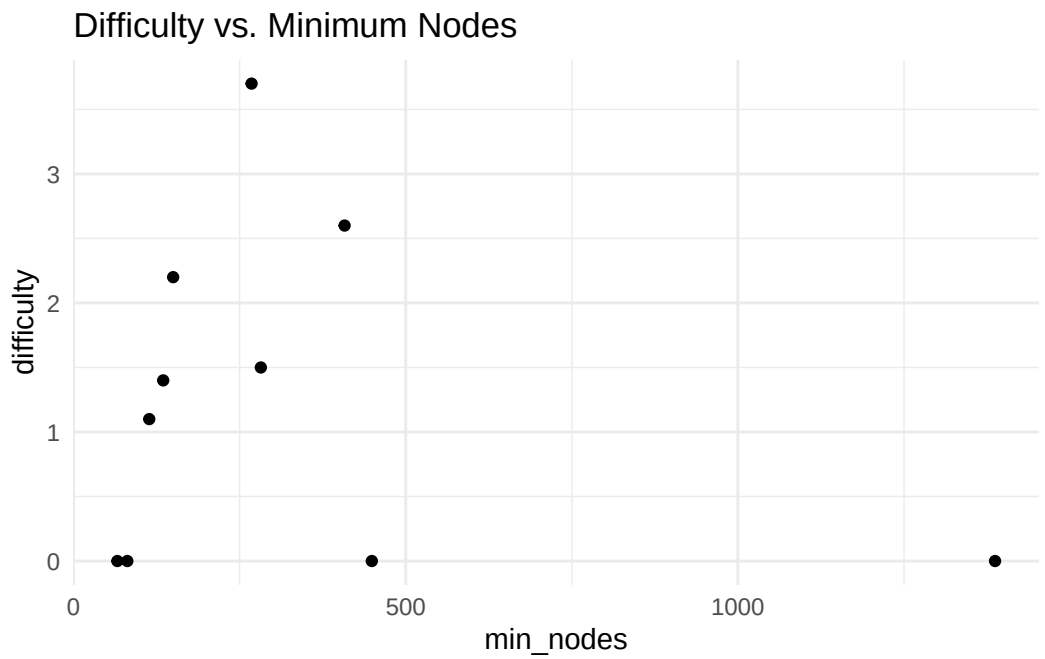



```
# density of points towards the minimum --> potential signal of correlation with difficulty
```

```
processed_rand_10_100 |>
  ggplot(aes(x = puzzle_id, y = nodes_explored)) +
  geom_point(alpha = 0.6) +
  geom_boxplot(aes(color = difficulty)) +
  coord_cartesian(ylim = c(0, 2000)) +
  labs(
    title = "Puzzles Ordered by Average Nodes Explored",
    x = "Puzzle ID (ordered by mean)",
    y = "Nodes Explored"
  ) +
  theme_minimal()
```




```
summary_stats |>
  ggplot(aes(x = min_nodes, y = difficulty)) +
  geom_point() +
  labs(title = "Difficulty vs. Minimum Nodes") +
  theme_minimal()
```



Sample of 100 Puzzles With 1000 Runs

Read Data:

```
rand_100_1000 <- read_csv(here("data", "rand_sample_100_1000.csv"))

data_100_1000 <- rand_100_1000 |>
  filter(is_solved == TRUE)

glimpse(data_100_1000)
```

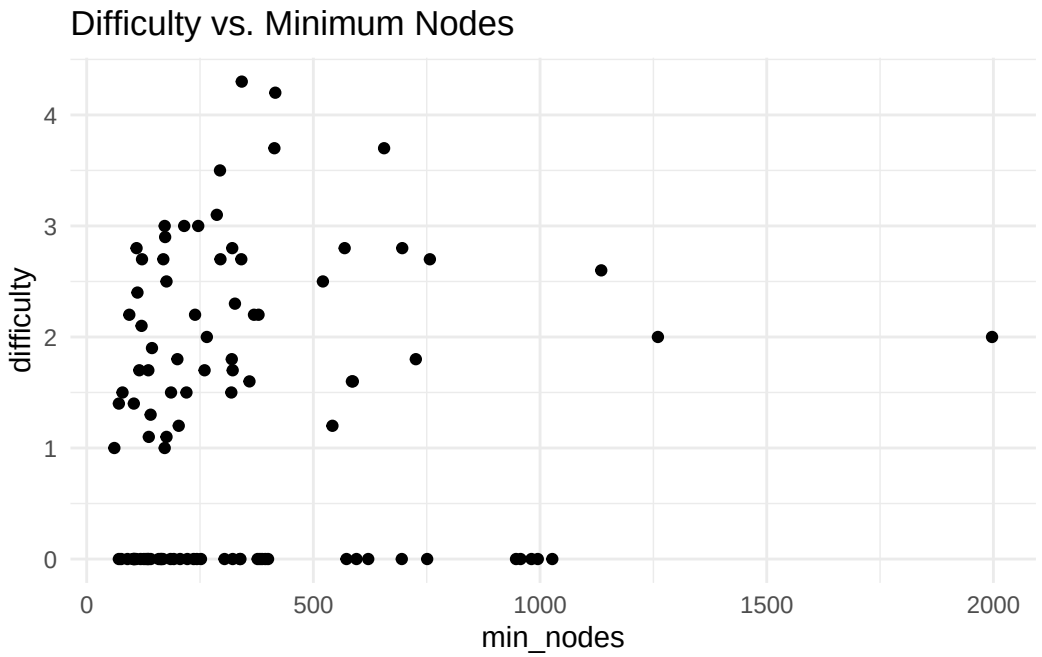
```
Rows: 100,000
Columns: 12
$ puzzle_id           <dbl> 2592480, 2592480, 2592480, 2592480, 2592480, 25924~
$ puzzle              <chr> ".32...1.....673.......4..9.524.3..7...6.9....3.8.~
$ clues               <dbl> 25, 25, 25, 25, 25, 25, 25, 25, 25, 25, 25, 25, 25~
$ difficulty          <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,~
$ run_id              <dbl> 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, ~
$ solutions_found     <dbl> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,~
$ nodes_explored      <dbl> 1884635, 432712, 446094, 701955, 39894, 368085, 44~
$ max_recursion_depth <dbl> 55, 55, 55, 55, 55, 55, 55, 55, 55, 55, 55, 55, 55~
$ solve_time_ms       <dbl> 254, 59, 58, 95, 5, 49, 59, 35, 27, 5, 1, 13, 20, ~
```

```
$ is_solved           <lgl> TRUE, TRUE, TRUE, TRUE, TRUE, TRUE, TRUE, TRUE, TR~
$ leaves              <dbl> 612792, 132501, 137045, 203027, 13686, 110393, 146~
$ backtracks          <dbl> 1884579, 432656, 446038, 701899, 39838, 368029, 44~
```

```r
summary_stats_2 <- data_100_1000 |>
  group_by(puzzle_id) |>
  summarise(
    mean_nodes = mean(nodes_explored),
    median_nodes = median(nodes_explored),
    sd_nodes = sd(nodes_explored),
    min_nodes = min(nodes_explored),
    max_nodes = max(nodes_explored),
    difficulty = mean(difficulty),
  ) |>
  arrange(mean_nodes)

summary_stats_2
```

```
# A tibble: 100 x 7
   puzzle_id mean_nodes median_nodes sd_nodes min_nodes max_nodes difficulty
       <dbl>      <dbl>        <dbl>    <dbl>     <dbl>     <dbl>      <dbl>
 1    129951     31279.       17647    39753.       319    325238        1.5
 2   1904125     47575.       10626   101472.       109   1031738        0
 3   1024839     60936.       22762.  107862.       206   1015090        0
 4    488499     62058.       36164.   83421.       369    934401        2.2
 5   1088996     67762.       20134.  118575.        79    910149        1.5
 6    433847     73797.       30296   125057.       243   1359362        0
 7    685704     90525.       51237   114782.       110    859138        2.8
 8   2474176     94381.       37882.  165938.       122   2431153        2.7
 9    462677     95502.       40043   150674.        94   1284353        2.2
10   2328642     96050.       27278   189960.       119   1998441        0
# i 90 more rows
```

```r
summary_stats_2 |>
  ggplot(aes(x = min_nodes, y = difficulty)) +
  geom_point() +
  labs(title = "Difficulty vs. Minimum Nodes") +
  theme_minimal()
```


Difficulty vs. Minimum Nodes
difficulty
min_nodes
0
1
2
3
4
0
500
1000
1500
2000