Wordle with Solver

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Code Accessibility

All the code you can found on my GitHub @WncFht.
Here is the repository: Wordle-with-Solver
And we have already released version 1.0.0.

Overview

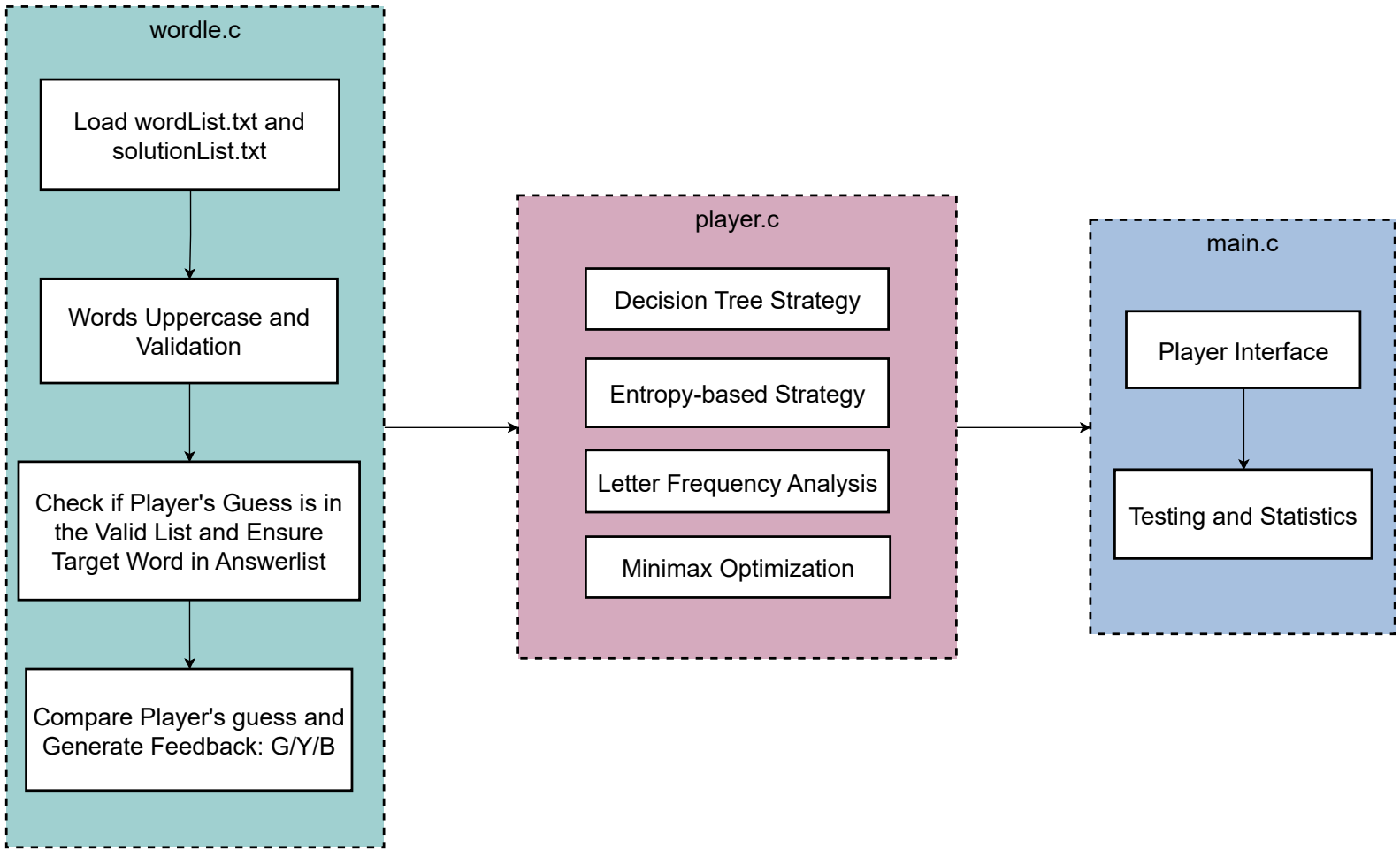


Figure: Overriew

Background

1. **Minimax**
   - Minimizes the maximum possible remaining solutions.
   - Good for worst-case scenario optimization.
2. **Frequency-based**
   - Uses letter frequency analysis.
   - Considers both position-specific and overall frequencies.
3. **Entropy-based**
   - Uses information theory to maximize information gain.
   - Starts with "STARE" as the first guess.

Minimax-Based Player

$$N_i(w) = \sum_{s \in S} \delta(P(w, s), P_i) \tag{1}$$

$$M(w) = \max_i N_i(w) \tag{2}$$

```
for (int i = 0; i < wordCount; i++) {
        generate_pattern_counts(wordList[i], pattern_counts);

        int max_remaining = 0;
        for (int j = 0; j < PATTERN_COUNT; j++) {
            if (pattern_counts[j] > max_remaining) {
                max_remaining = pattern_counts[j];
            }
        }

        if (max_remaining < min_worst_case) {
            min_worst_case = max_remaining;
            strcpy(best_guess, wordList[i]);
        }
    }
```

Frequency-Based Player

$$\text{score}(w) = \sum_{j=1}^{k} (2 \cdot \text{letter\_freq}[L_j][j]) + \sum_{L \in w \text{ (unique)}} \text{total\_freq}[L] \quad (3)$$

$$w_{\text{best}} = \arg\min_{w} M(w) \quad (4)$$

```
for (int i = 0; i < wordCount; i++) {
        float score = 0.0f;
        int used[26] = {0};

        for (int j = 0; j < WORD_LENGTH; j++) {
            int letter = wordList[i][j] - 'A';
            score += letter_freq[letter][j] * 2.0f;  // Position-specific score

            if (!used[letter]) {
                score += total_freq[letter];  // Overall letter frequency score
                used[letter] = 1;
            }
        }
```

Understanding Information Entropy

1. Information Entropy Calculation Formula

$$H(X) = -\sum_{i=1}^{n} p(x_i) \log_2 p(x_i) \tag{5}$$

where $p(x_i)$ is the probability of event x_i occurring.

Entropy Strategy Overview

Initialize solution set. For each guess:

- Update possible words.
- Calculate entropy.
- Pick word with highest entropy.

This approach ensures the most informative guess.

Code Implementation

```
1  static float calculate_entropy(int* pattern_counts) {
2      float entropy = 0.0f;
3      for (int i = 0; i < PATTERN_COUNT; i++) {
4          if (pattern_counts[i] > 0) {
5              float p = (float)pattern_counts[i] / solution_count;
6              entropy -= p * log2f(p);
7          }
8      }
9      return entropy;
10 }
11
```

Code for Entropy Calculation

Strategy Essentials

Optimal guess $\rightarrow$ Entropy & Probability.

Weighted Entropy for Global Optimality

Local entropy maximization may not guarantee global optimality.
Thus, we weight future entropy for a more informed guess.

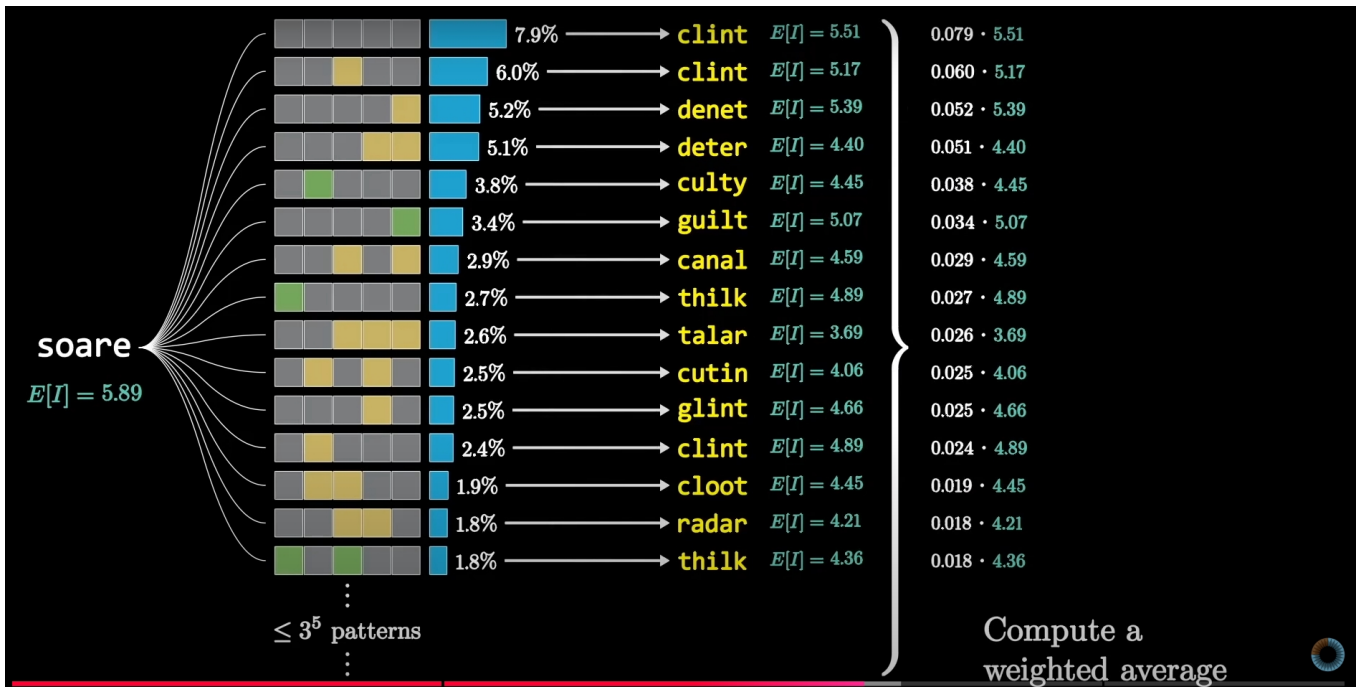


Figure: Image source: 3blue1brown

Decision-Tree-Based Player

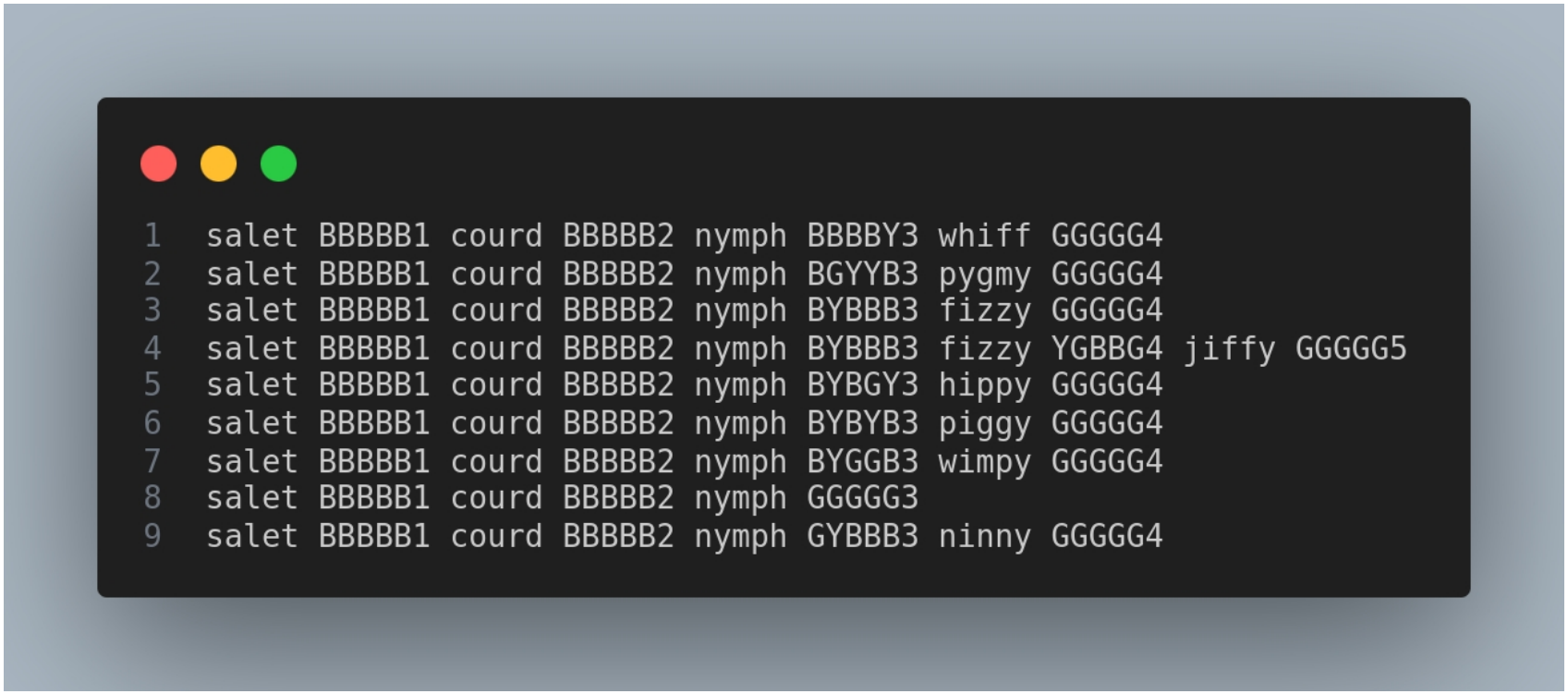


Figure: Decision Tree

Code

1. **Initial Move:**
   - Always starts with `"SALET"` as the first guess.
2. **Pattern Tracking:**
   - Maintains a cumulative pattern of guesses and feedback.
   - Format: `<WORD> <PATTERN><LEVEL> ...`
   - Example: `SALET GYBBG1 CRANE GBBBY2`
3. **Decision Making:**
   - Consults `tree.txt` for the next optimal move.
   - Chooses the statistically best next word.

Core Function

```c
static const char* find_next_move(const char* feedback, int level) {
    // Append new pattern to cumulative pattern
    char new_pattern[32];
    sprintf(new_pattern, "%s %s%d ", current_word, feedback, level);
    strcat(cumulative_pattern, new_pattern);

    printf("Looking for pattern: '%s'\n", cumulative_pattern);

    // Search for matching line
    for (int i = 0; i < line_count; i++) {
        if (strstr(decision_lines[i], cumulative_pattern) == decision_lines[i]) {
            // Extract next word
            const char* line = decision_lines[i] + strlen(cumulative_pattern);
            char next_word[WORD_LENGTH + 1];
            if (sscanf(line, "%5s", next_word) == 1) {
                printf("Found next word: %s in line: %s\n", next_word, decision_lines[i]);
                return strdup(next_word);
            }
        }
    }

    printf("No matching move found\n");
    return NULL;
}
```

Figure: function:find_next_move

Compare Guess Distribution

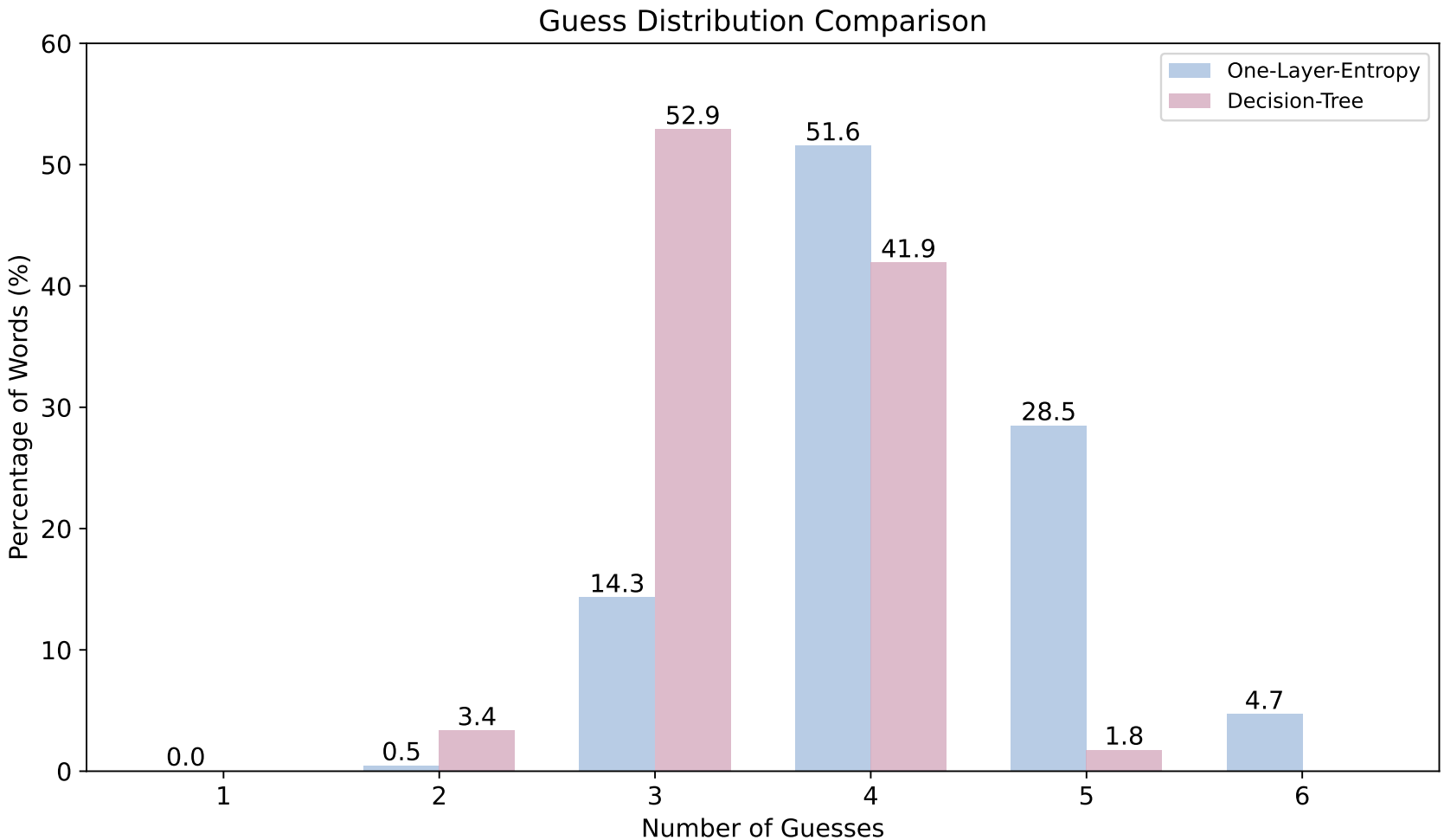
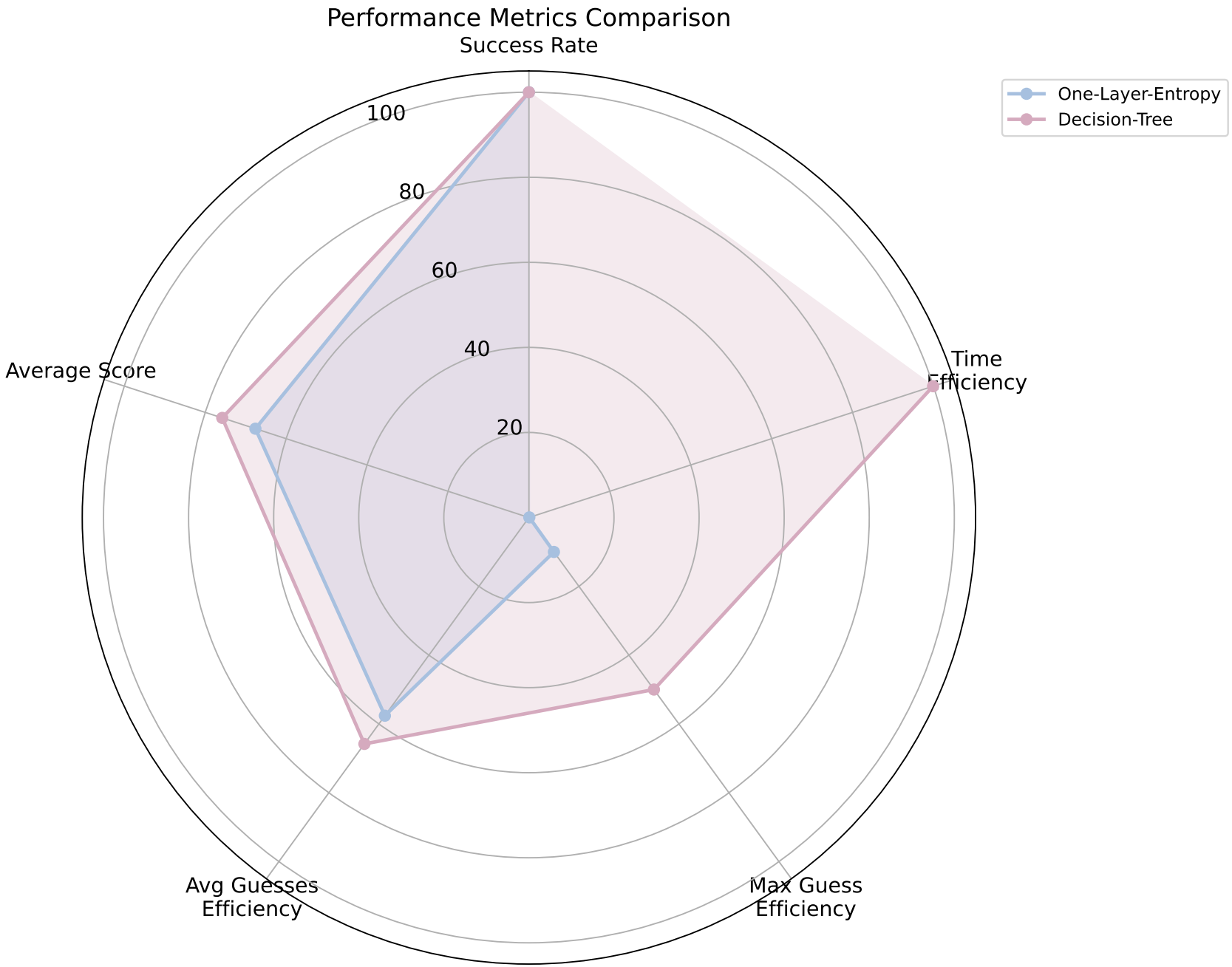


Figure: Compare Guess Distribution

Performance Metrics



References

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3Blue1Brown (n.d.[a]). *Mistake Clarification*. URL: https://www.youtube.com/watch?v=fRed0Xmc2Wg.


— (n.d.[b]). *Solution to a Math Problem*. URL: https://www.youtube.com/watch?v=v68zYyaEmEA.


Selby, Alex (n.d.). *The Best Strategies for Wordle*. https://sonorouschocolate.com/notes/index.php?title=The_best_strategies_for_Wordle. Accessed: 2024-11-26.

Use of AI

Kimi:

- **Prompt1:** How to solve Wordle and give me some ideas.
- **Prompt2:** Please refactor my code and add some annotation.