Mastermind with a Deceptive Code-Maker

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Introduction

Mastermind is an extremely addictive ‘code breaking’ game for two players - here one player creates a secret code (code-maker) and the other (code-breaker) attempts to determine the secret code based on a set of hints/responses. Under correct (truthful) responses from the code-maker, the code-breaker can easily decode the message in five moves or fewer (e.g., Knuth’s algorithm). We consider an interesting modification where the code-breaker is uncertain about the correctness of the code-maker’s responses - here one player creates a secret code (code-maker) and the other tries to break the code by making guesses, i.e., submitting one code. Following each guess, the code-maker answers using up to four pegs of two colors:

• A black peg means that a guess peg matches both color and position of a code peg.

• A white peg means that a guess peg matches the color but not the position of a code peg.

Examples/Walk Through

Following an incorrect guess (guess/score) the code-breakers removes from S (the set of all possible solutions) any element that would not give the same response if it (guess/score) were the secret code.

When to Lie/Best Lie - Consistency Approach

By determining the frequency of values, [1, 2, 3, 4, 5, 6], occurring in the set of possible solutions a player selects the guess that most closes aligns with the maximum frequencies of values.

When to Lie/Best Lie - Frequency Approach

Games cycled through all possible secret codes, lies, and round of lie. Individual cells represent (EL, ML).

When to Lie/Best Lie - Consistency Approach

Games cycled through all possible secret codes (4^6 = 1296 games). EL = Expected Length (mean number of rounds) and ML = Maximum Length (maximum number of rounds)

When to Lie/Best Lie - Frequency Approach

Games cycled through all possible secret codes, lies, and round of lie. Individual cells represent (EL, ML)

Figure 1: Mastermind box art and game boards since 1970 (game launch)

Figure 2: Example games with guesses based on the consistency approach.

Figure 3: Tree diagram of game play with secret code [5, 4, 3, 3], initial guess [1, 1, 1], and future guesses determined based on the consistency approach.

Figure 4: Example games with guesses based on the frequency approach.

Figure 5: Game stats cycling through all possible secret codes (4^6 = 1296 games). EL = Expected Length (mean number of rounds) and ML = Maximum Length (maximum number of rounds)

Figure 6: Game stats with an initial guess of [1, 1, 1, 1] and future guesses determined via the consistency approach. Games cycled through all possible secret codes, lies, and round of lie. Individual cells represent (EL, ML)

Figure 7: Game stats cycling through all possible secret codes (4^6 = 1296 games). EL = Expected Length (mean number of rounds) and ML = Maximum Length (maximum number of rounds)