

# Mastermind AI

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CS 541 Artificial Intelligence

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# Greedy Local Search

- Knowledge = past history of guesses and responses
- Derived set of remaining consistent solutions
  - Goal: Reduce set to a single guess
- What's the “best” guess we can make?
  - Best = provides the most information regardless of the response we get

$$H(X) = - \sum_{i=1}^k p_i \ln p_i \quad \text{Best Guess}$$

- Entropy = measure of information content
- Guessing divides the current set of consistent solutions into partitions based on 14 different possible responses
- $\Delta\text{Entropy}$  = Gain in information content

$$\ln n - \frac{1}{n} \sum_{i=1}^{14} n_i \ln n_i$$

- Secondary heuristic: # of nonempty partitions

		Avg. Game Length	
Response	Count	MostParts	Entropy
0.0	360	5.025	5.03056
0.1	1440	5.54722	5.54792
0.2	1260	5.43968	5.42222
0.3	264	5.0303	4.87879
0.4	9	3.55556	3.55556
1.0	480	5.00625	4.99792
1.1	720	5.20694	5.18333
1.2	216	4.96296	4.77315
1.3	8	3.75	3.75
2.0	180	4.67222	4.7
2.1	72	4.36111	4.36111
2.2	6	3.66667	3.66667
3.0	24	4.04167	4.04167
4.0	1	1	1
Overall Stats	5040	5.26587	5.24286

# Speedup!

- Can't try all 5040 guesses; it takes too long!
- Warning: do not just use consistent guesses
  - Inconsistent guess may yield more information than a consistent one
- Idea: eliminate redundant guesses
  - Guesses that provide the same increase in information
  - Two guesses are *equivalent* if we can find a transformation between them that respects a past history
    - Substitution and permutation; remapping of symbols

# Representative Guesses

- No past history = all guesses are equivalent
  - Just guess 0123 (it represents all other guesses)
- Example with past history (0123,  $r_1$ )
  - 0124  $\sim$  0125 (both 4 and 5 are uncalled digits)
  - 0124  $\sim$  0153 (both just change a single digit)
  - 0124  $\not\sim$  0145 (different # of changed digits)
- Just need to try 1 member from each equivalence class
- Precompute equivalence classes
- Rely on absent and uncalled digits when not available

# Performance

- Average # of guesses: **5.24286**
- Time to run all  $10*9*8*7 = 5040$  different games: just under **16 minutes**