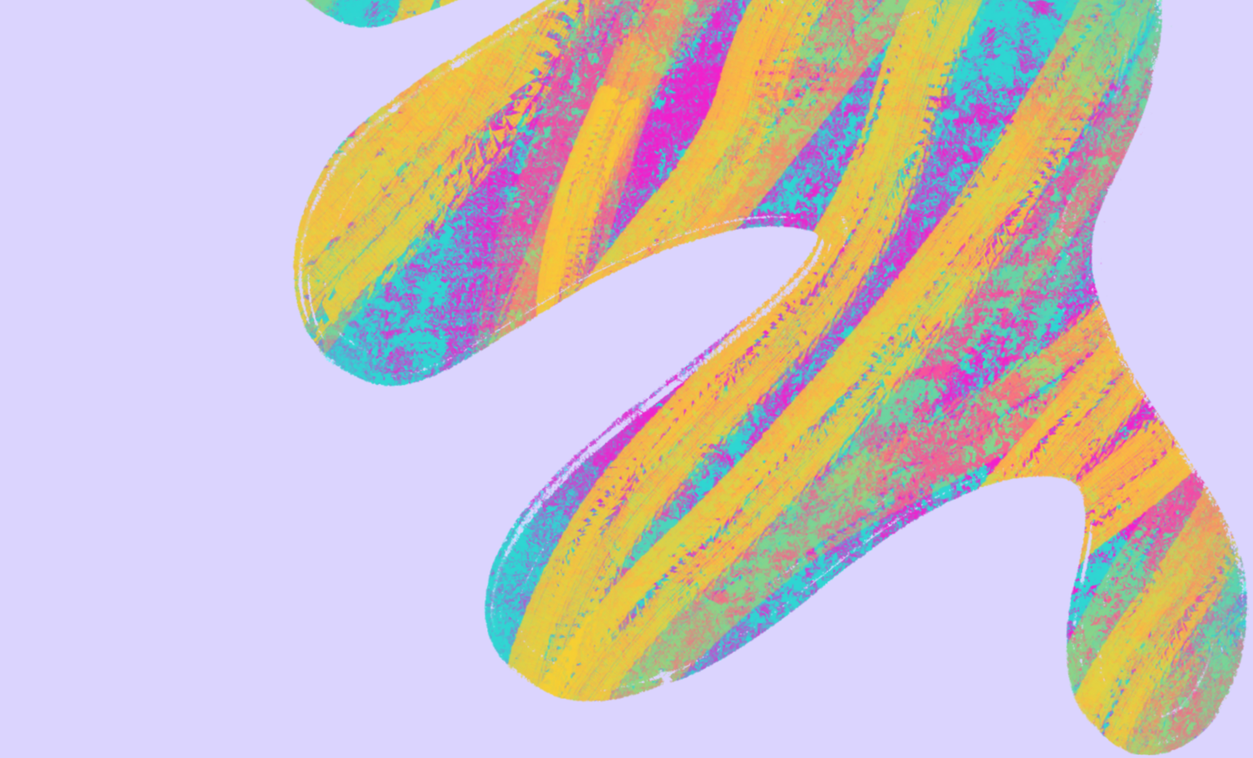
Mastermind: AI Project

Team Members:

- *R Amogh*
- *Rahul Anand*
- *Siddharth Singh*
- *Krutay Upadhyay*
- *Subhash Chandra Ponnam*
- *Amogh R*

Mentor:

Sadock Chakma



Outline

Code breaking algorithms and applications

- ***Introduction and Motivation***
- ***Known Strategies.***
- ***Statistics***
- ***Practical Applications***
- ***References***

What is Mastermind?

- A “code-breaking” game, similar to Wordle.
- Code-maker v/s Code-breaker (You!)
- Standard mastermind: 6 colours, 4 columns
- Limited number of guesses
- Feedback using the placement of colours (how many in right place, how many in wrong place)
- Possible combinations - Increases exponentially with number of colours

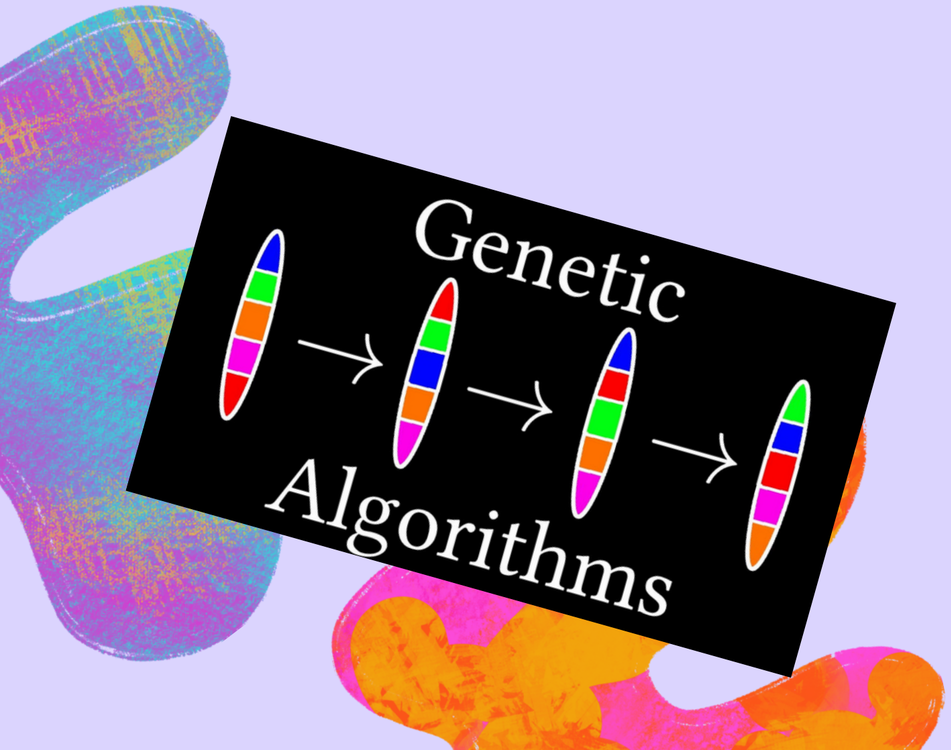
Known Strategies

Donald Knuth - Consistency

- Strategically optimal algorithm
- Guaranteed to hit in less that 6 guesses
- *Very slow*

Guervos et al. - Evolutionary Algos

- Fitness function - Difference or Distance
- Stepwise optimal - Minimize distance to a consistent combination
- Immediate guessing



Berghman et al. - Eligible Set

- Eligible set v/s Immediate guess
- Reducing eligible set size
- Increasing fitness with number of guesses

Belal and Bestavros

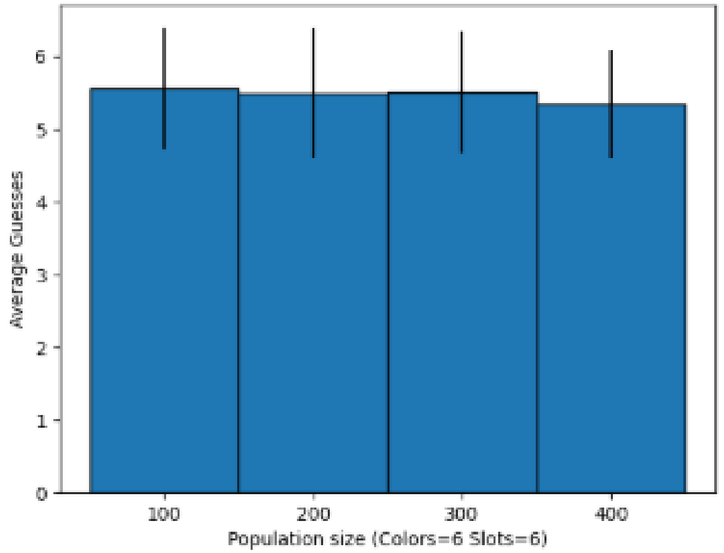
- Maximizes minimum information gain
- Optimized for upper bound on guesses
- Lookahead strategy - Predicts pools of eligible sets

Evolutionary Algorithms

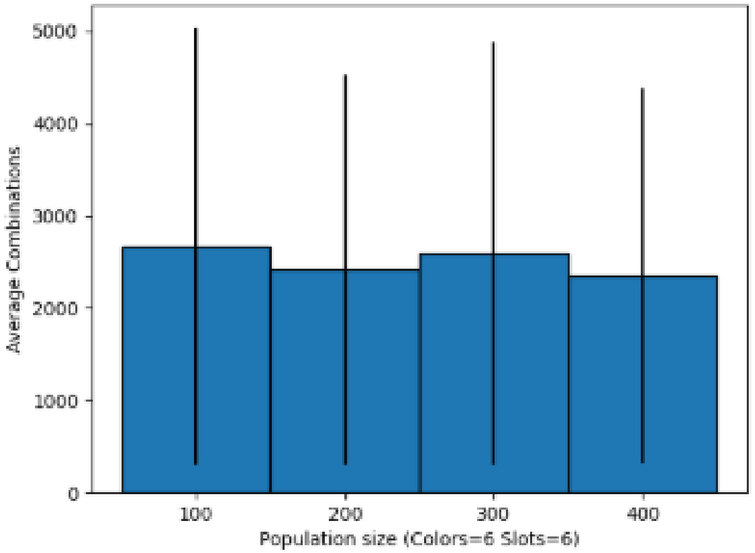
- Generations, Populations
- Crossover, Mutations and non-determinism
- Fitness functions - Picking out the best
- Convergence - Dependence on population size and number of generations
- Hyperparameters: Dependence of speed on population size

Performance Metrics - GenMM vs Knuth

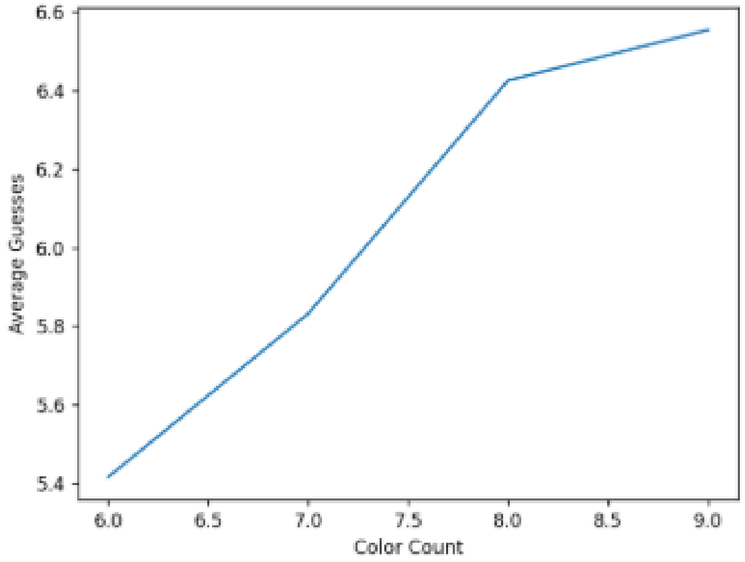
Algorithm	Average Guesses	Average Evaluated Combinations
GenMM(1)	4.67	316
GenMM(2)	4.60	307
Knuth’s MM	4.76	All



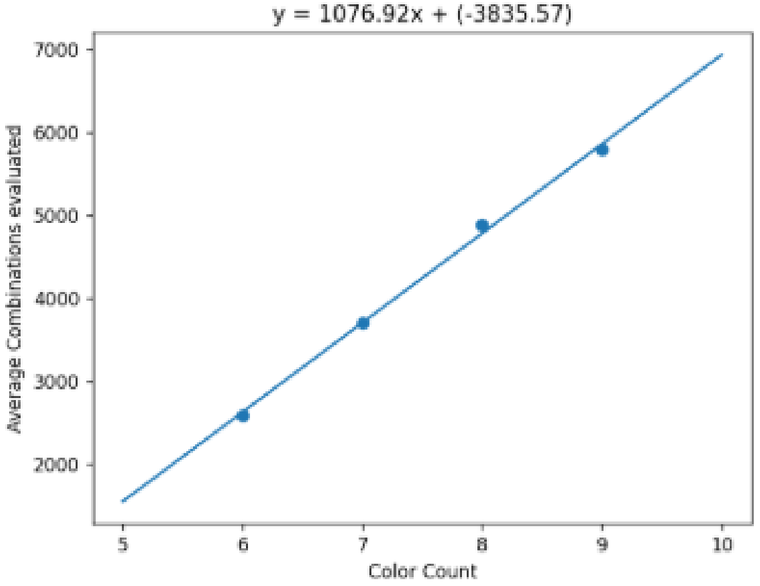
(a) Average Guess vs Population Size



(b) Average Combinations Evaluated vs Population Size

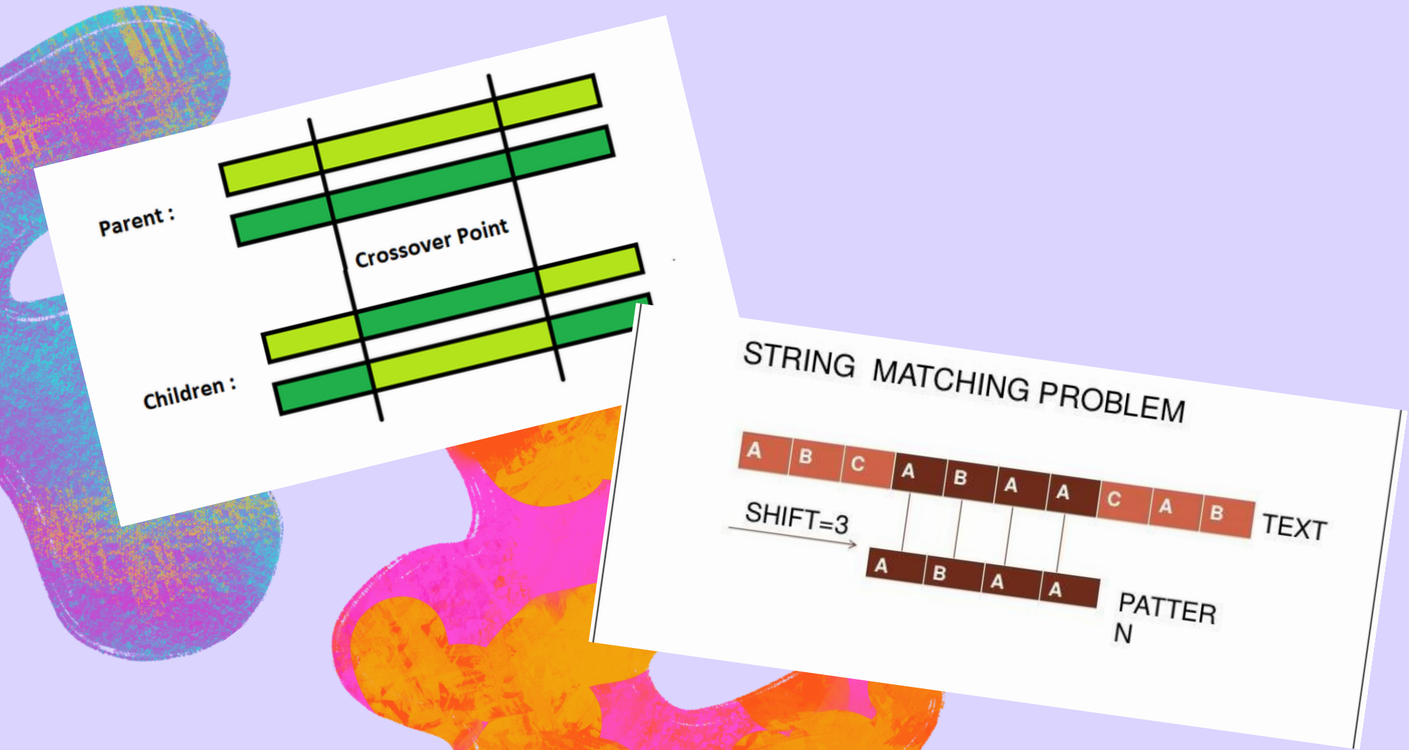


(c) Average Guess vs Color Count



(d) Average Combinations Evaluated vs Color

Novel Ideas for Practical Applications



Fuzzy Hash Reversal

- Applications in cybersecurity
- Easier version of a hash reversal problem
- Converting a problem of similarity checks to one of string creagenerationtion

Unlimited Queries - Limited Time

- String - Hash dataset
- Eligible parents, *closeness* vs *difference scores*
- Iterative difference reduction, stiching vs crossover

Protein Reverse Translation

- Biological analog of a codemaker
- Fixed codon possibilites, large search space

Mutation Detector

- DNA mutations, parent DNA search via protein differences

Thank you!

References:

- *Knuth, Donald - "The Computer as Master Mind"*
- *Berghman, Lotte - "Efficient solutions for Mastermind using genetic algorithms"*
- *Merelo J.J.; Mora A.M.; Cotta .; Fernández-Leiva A.J. - "Finding an Evolutionary Solution to the Game of Mastermind with Good Scaling Behavior"*
- *Merelo-Guervós, J.J., Runarsson, T.P. - "Finding Better Solutions to the Mastermind Puzzle Using Evolutionary Algorithms"*
- *Bestavros, Belal - "MasterMind: A game of Diagnosis Strategies"*