Genetic Algorithms

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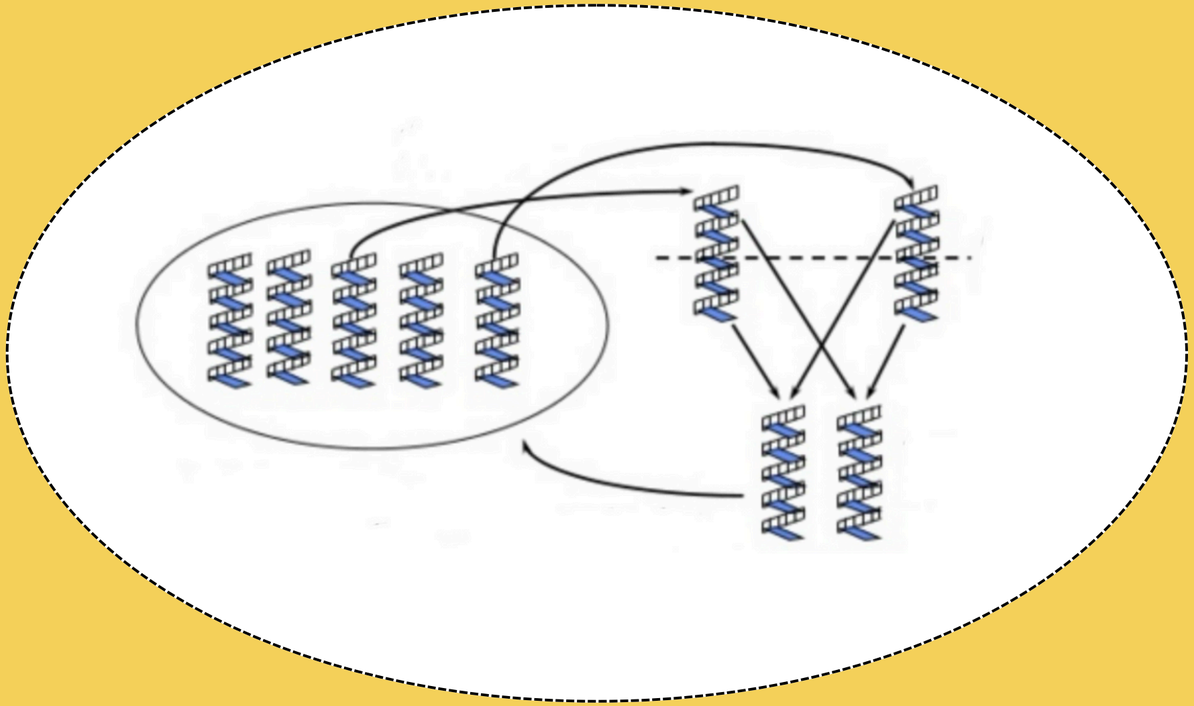
Mathematic For Machine Learning

WHAT GENETIC ALGORITHMS?



- Evolution-inspired optimization
- Population of candidate solutions
- Improves over generations
- Non-differentiable problems
- Large & complex search spaces
- Traditional optimization fails

APPLICATIONS

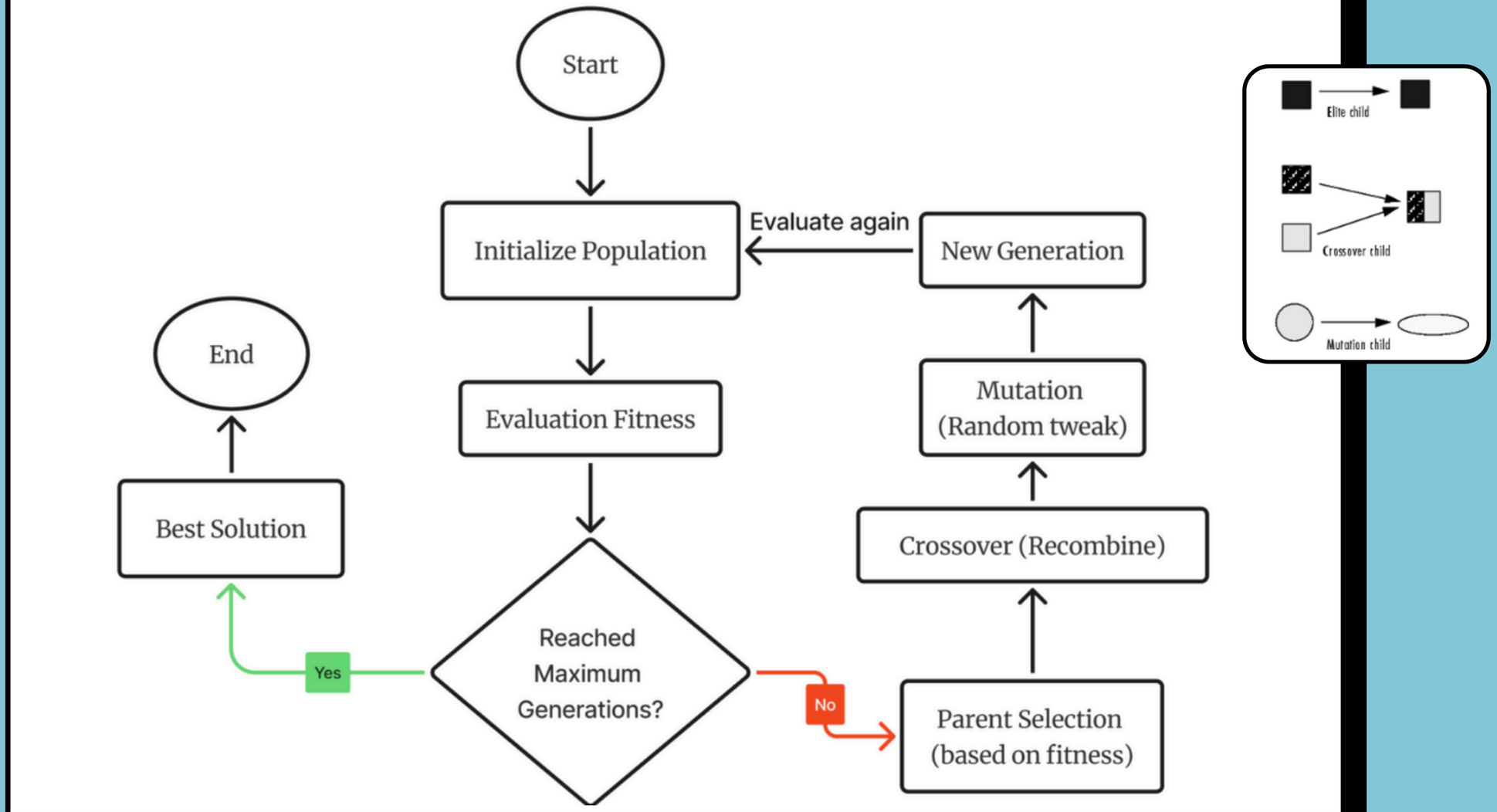
1. Machine Learning Hyperparameter Tuning

- No gradient with respect to hyperparameters
- Exhaustive search is too expensive
- Performance surface is irregular

2. Scheduling & Timetable Optimization

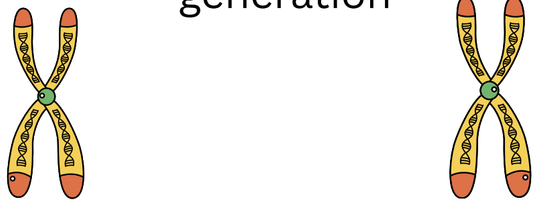
- Time conflicts & Resource limits
- Fairness constraints
- Air Flight Schedule Planing
- MRT train Schedule

GENETIC ALGORITHM WORKFLOW



MATHEMATIC INVOLVED

- **Optimization**
- **Probability**
- **Representation and Search Space**
- **Elitism:**
  the best solution survives to the next generation



Formula 1: Fitness Function

$$f(i) = fitness\ of\ individual\ i$$

defines what to optimize

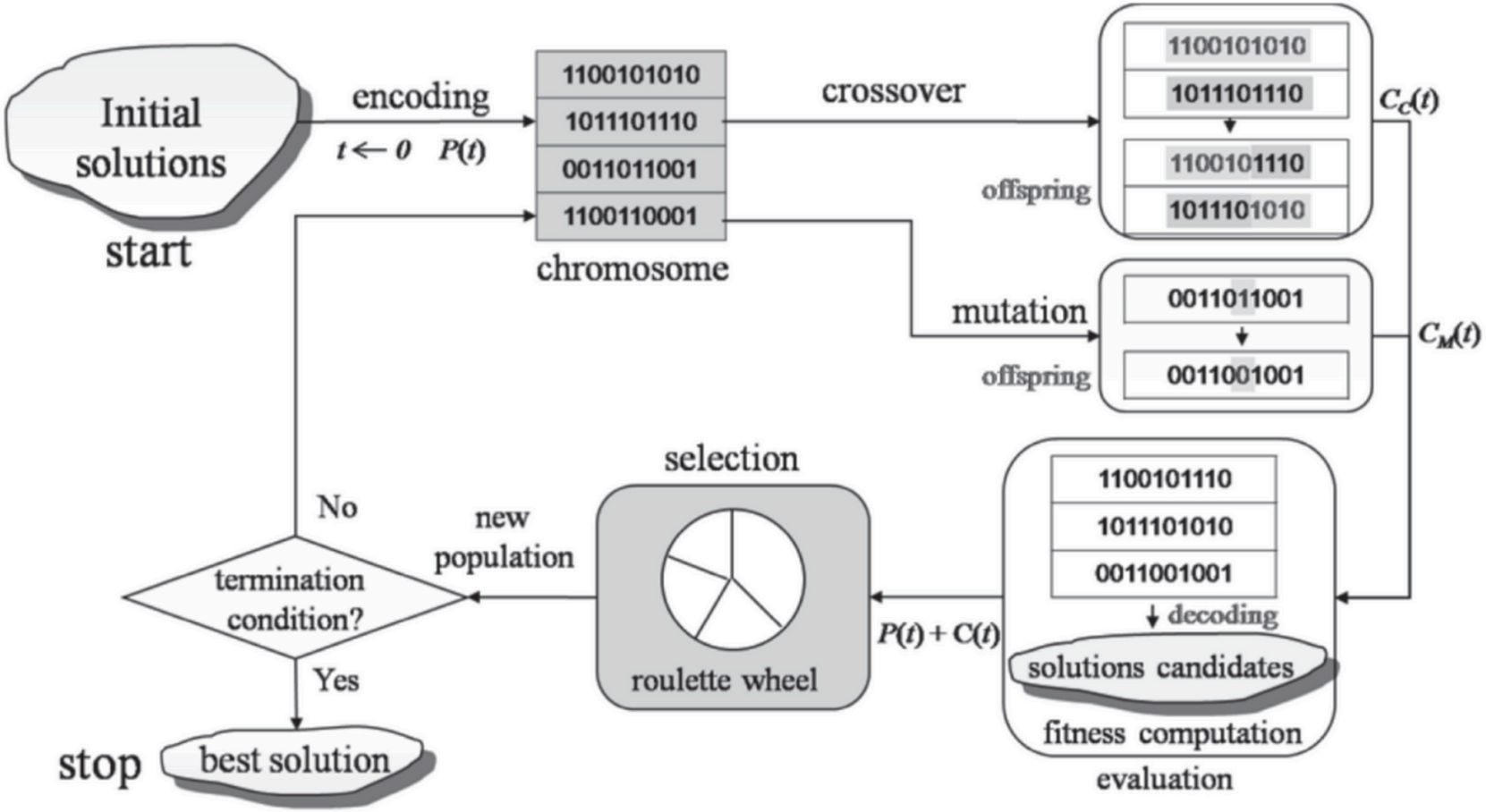
Formula 2: Selection Probability Function

$$P(i) = \frac{f(i)}{\sum_{j=1}^{N} f(j)}$$

Where: $P(i)$ = probability of selecting solution i
$f(i)$ = fitness of solution i
N = population size

- Roulette-wheel selection
- Higher fitness → higher selection chance

GENETIC ALGORITHM WORKFLOW



Khadwilard, A. (2011). Application of genetic algorithm for optimisation problems. RMUTP Research Journal, 5(2), 153–163.

STRENGTH AND LIMITATION

Strenght

- ✓ Robust and flexible optimization
- ✓ No gradient requirement
- ✓ Global search capability

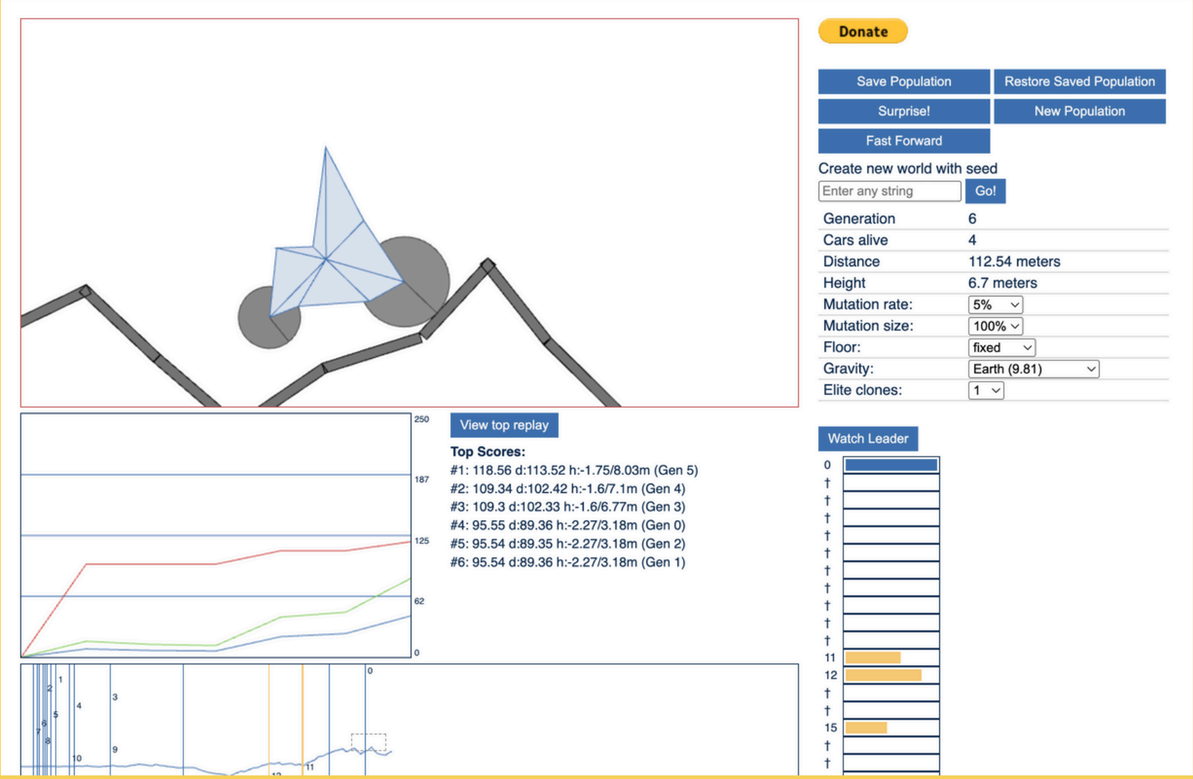
Limitation

- ⚠ Parameter sensitive
- ⚠ No optimality guarantee
- ⚠ Risk of premature convergence

IMPLEMENTATION OVERVIEW

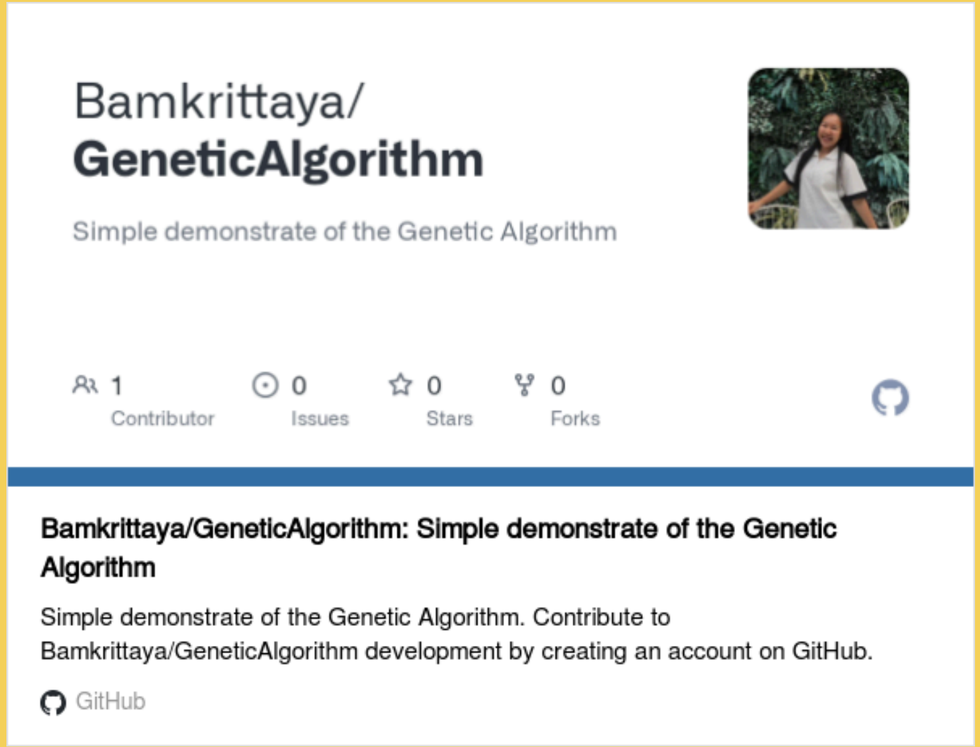
Example of the Genetic Algorithm finding the best car components

https://rednuht.org/genetic_cars_2/



Hyperparameter Tunning

https://github.com/Bamkrittaya/GeneticAlgorithm



CONCLUSION & FUTURE WORK

→ GA provides a practical approach to hyperparameter tuning
→ Evolution occurs despite non-monotonic performance
→ Randomness supports exploration in noisy search spaces
→ Simple arithmetic and probability drive effective optimization

Future: Adaptive mutation & Hybrid methods