A Leveled Mentorship Approach to Genetic Algorithms for the Travelling Salesman Problem

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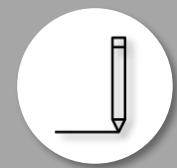

INTRODUCTION

Genetic Algorithms

- Modeled by the survival of the fittest mentality
- Transforms a population of hypotheses or candidate solutions
- Goes through stages of operations which are repeated over generations

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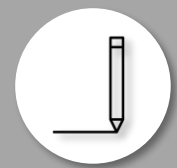
Traveling Salesman Problem

- Given a list of cities and the distances between each pair of cities, what is the shortest path?
- Typically uses Euclidian Distance on typical datasets
- Applications of vehicle routing, drilling of printed circuit boards, etc







Related Works

Generic Genetic Algorithm

- Roulette Wheel Selection

$$\Pr(h_i) = \frac{Fitness(h_i)}{\sum_{j=1}^{p} Fitness(h_j)}$$

- Does not use selection as parents

Linear Rank Selection

- Variation of Roulette Wheel Selection
- Based on the rank of an individual rather than it's fitness
- $\Pr(h) = \frac{rank(h)}{n*(n-1)}$

Tournament Selection

- Pits individuals against each other and the highest fitness individual is selected as a parent
- Most methods use this to select parents for crossover

Downfall

These methods have some variance to their selection of hypotheses but ultimately does not guarantee diversity

Approach

Operation Modifications
Change on crossover and mutation

Leveled Selection
Separate individuals into levels

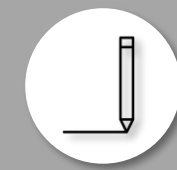
Regular Crossover
Apply standard crossover

Mentored Crossover
Use best individuals for crossover







Approach

Operation Modifications

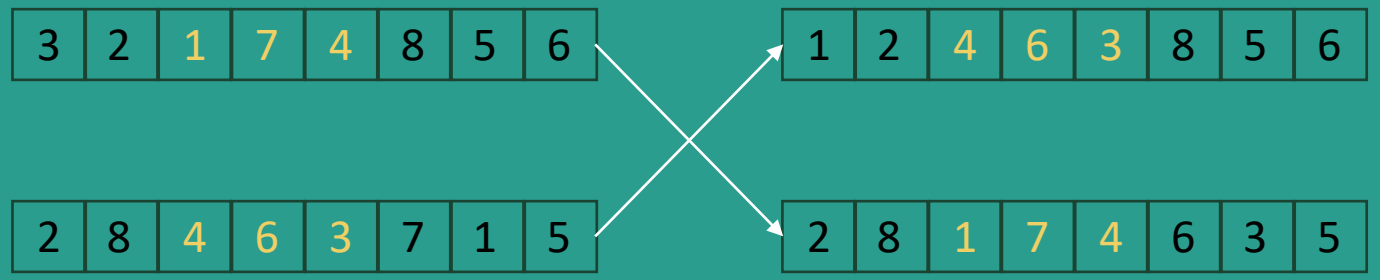
Crossover

Partially Mapped Crossover (PMX)

- Take parents and make copies of them
- Swap subpath of copies
- Use subpath as maps
- Use maps to fix duplicates

Mapping

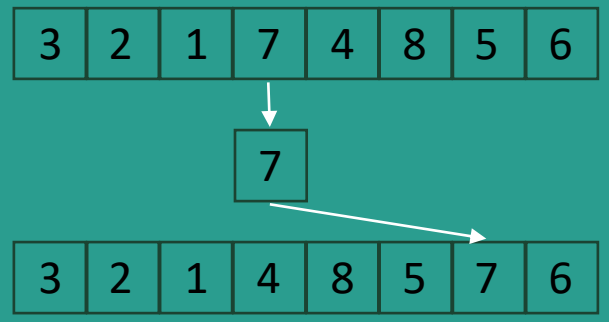
1 → 4
7 → 6
4 → 3



Mutation

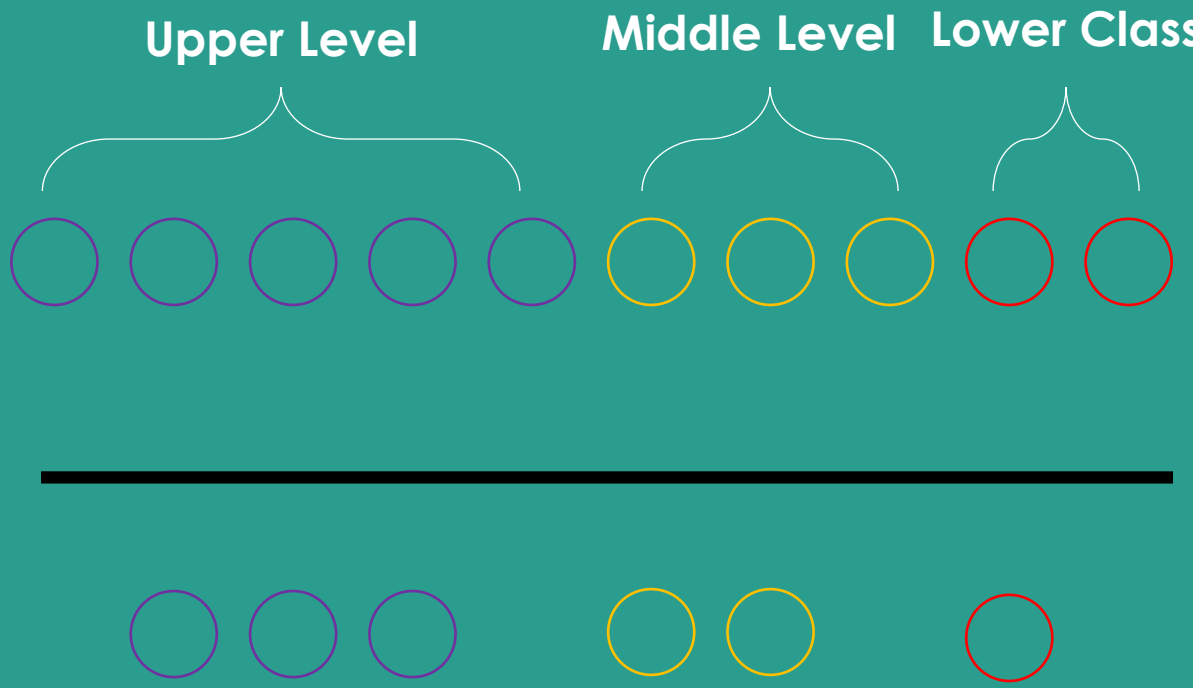
Insertion Mutation

- Randomly choose a city
- Remove city from path
- Place chosen city in a new position of path



Approach

Leveled Selection



Method

- Sort population based on fitness (asc order)
- Separate into upper, middle and lower class
- For each class, use Roulette Wheel Selection to pick individuals
- RWS Fitness

$$\Pr(\mathrm{h}) = 1/Fitness(h)$$

Regular Crossover

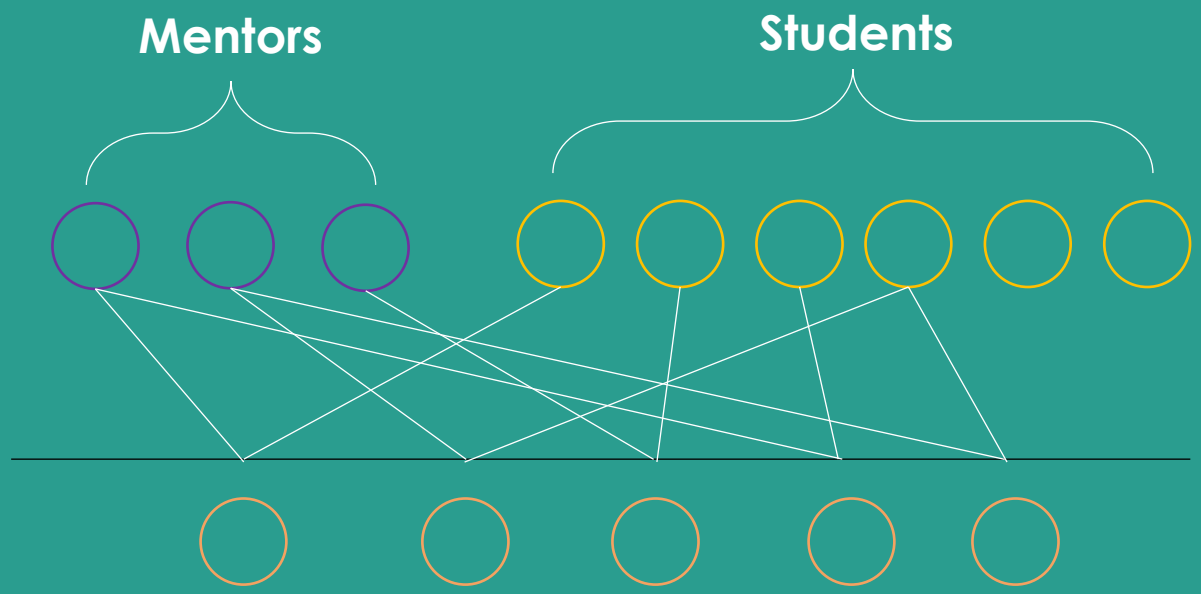
Approach

- A portion of the population size is used for the typical crossover operation
- Parents are probabilistically selected using RWS
- Parents are taken from Ps, the individuals selected from the Leveled Selection

Approach

Mentored Crossover

- Sort population P, based on fitness
- Select m best individuals as mentors
- Select Parent 1 from list of mentors
- Select Parent 2 randomly from sorted population that is not in mentor list



Evaluation Criteria / Parameters

Metrics

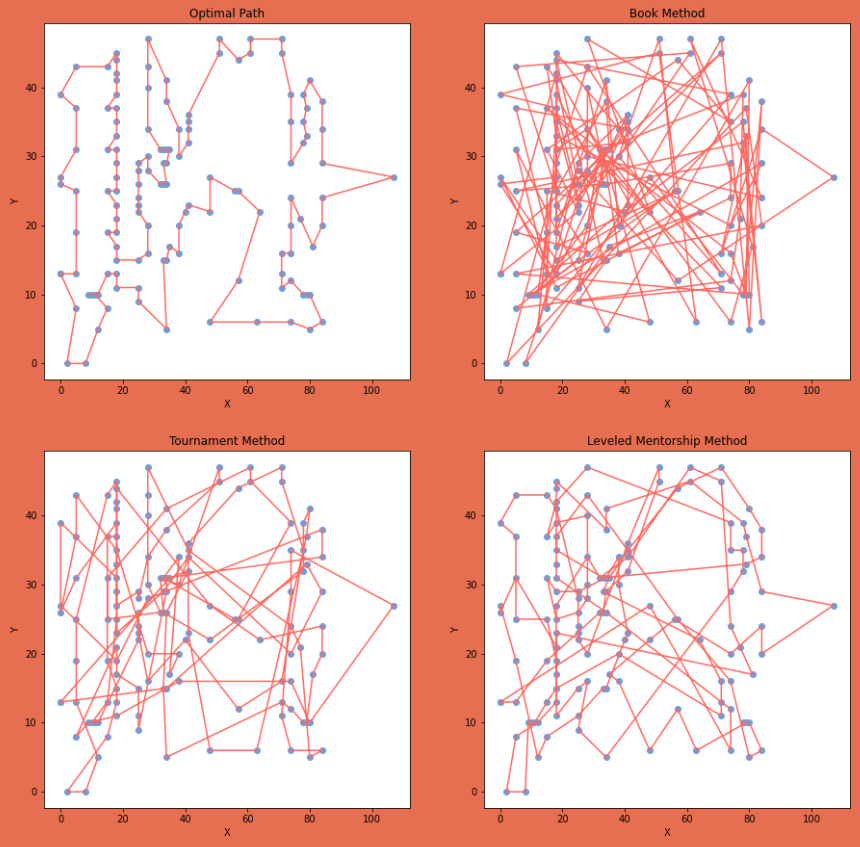
- Visual Evaluation on the Path
- Best Fitness Per Generation
- Average Fitness Per Generation
- Diversity Score
- Over 3 Iterations/Runs using xqf131 and xqg237

Parameters

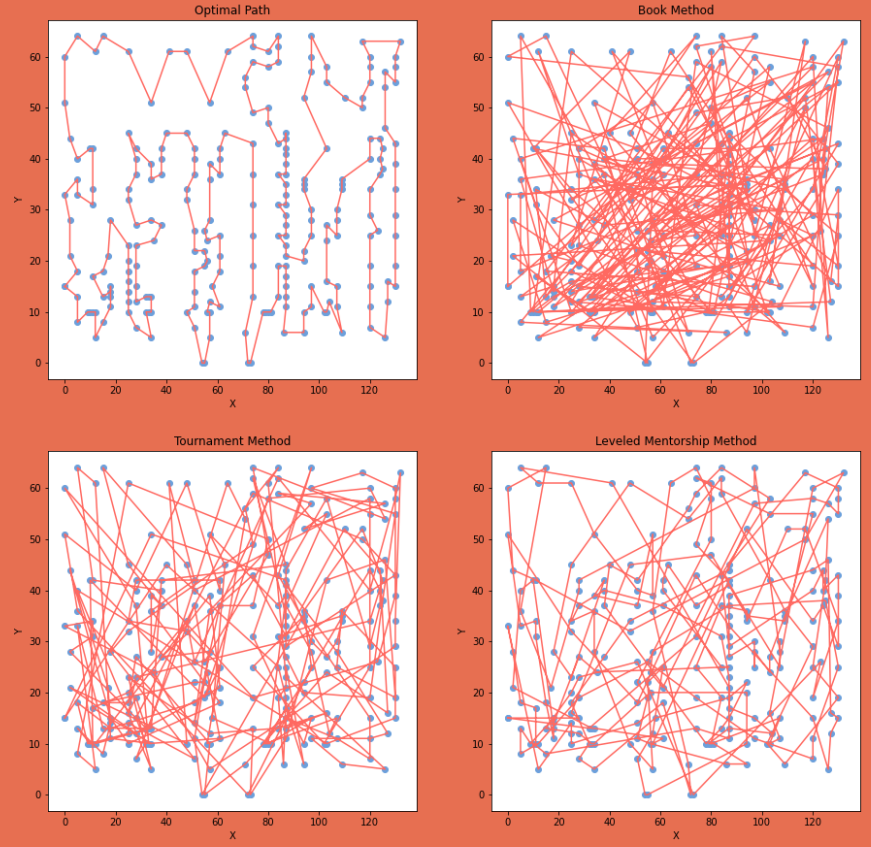
- Initial Population: 1024 Individuals
- Population Size: 300
- Number of Generations: 500
- Crossover Prop = 0.7
  Mutation Rate = 0.2
- Level Split: (0.6, 0.3, 0.1)

Results

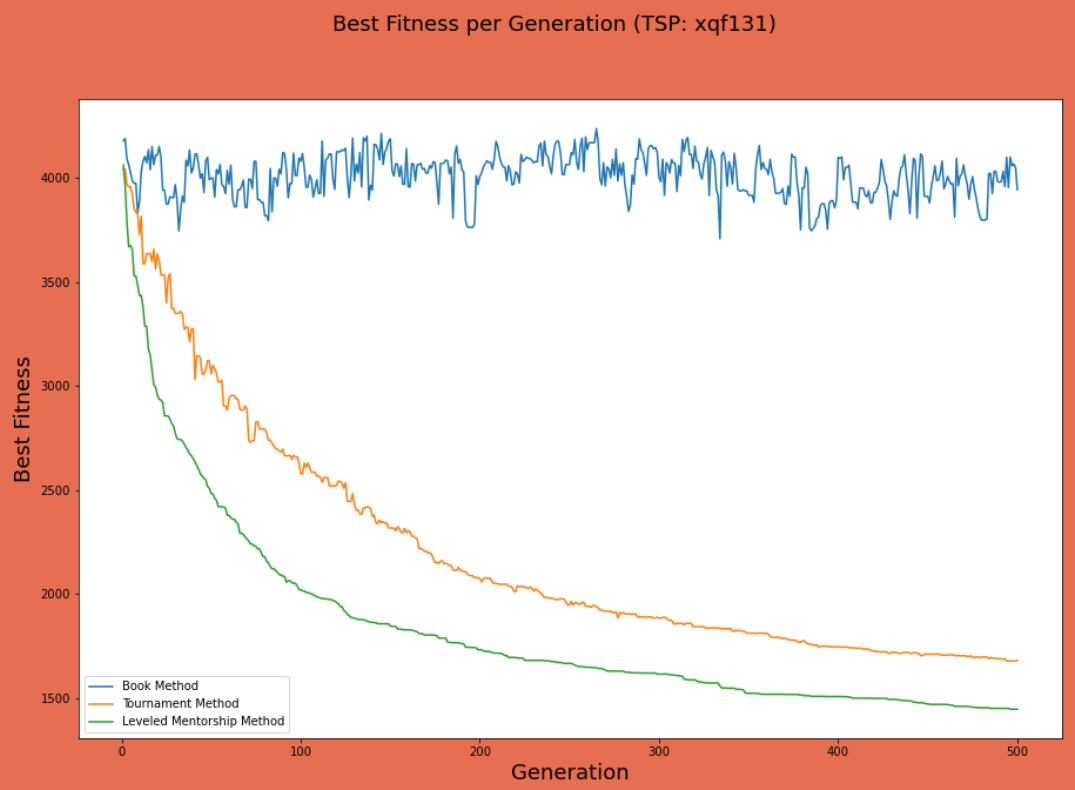
Mapped Path for xqf131

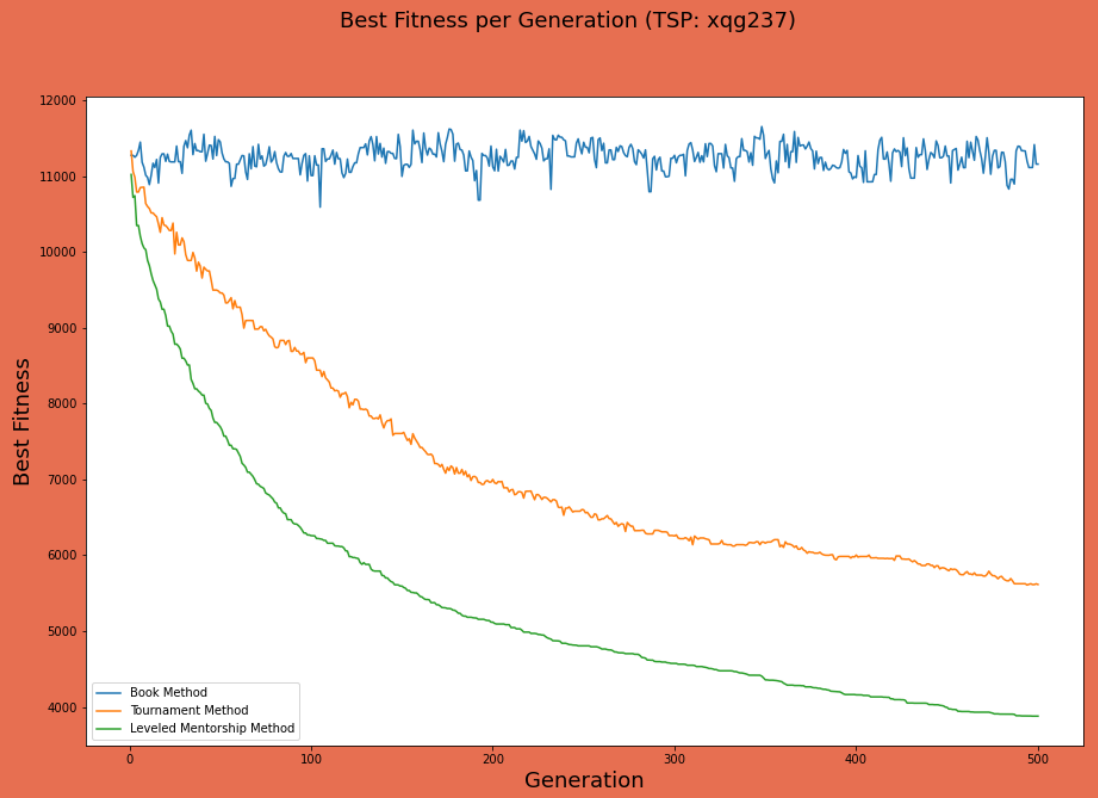


Mapped Path for xqg237



Results


Best Fitness per Generation (TSP: xqf131)
Best Fitness
Generation
Book Method
Tournament Method
Leveled Mentorship Method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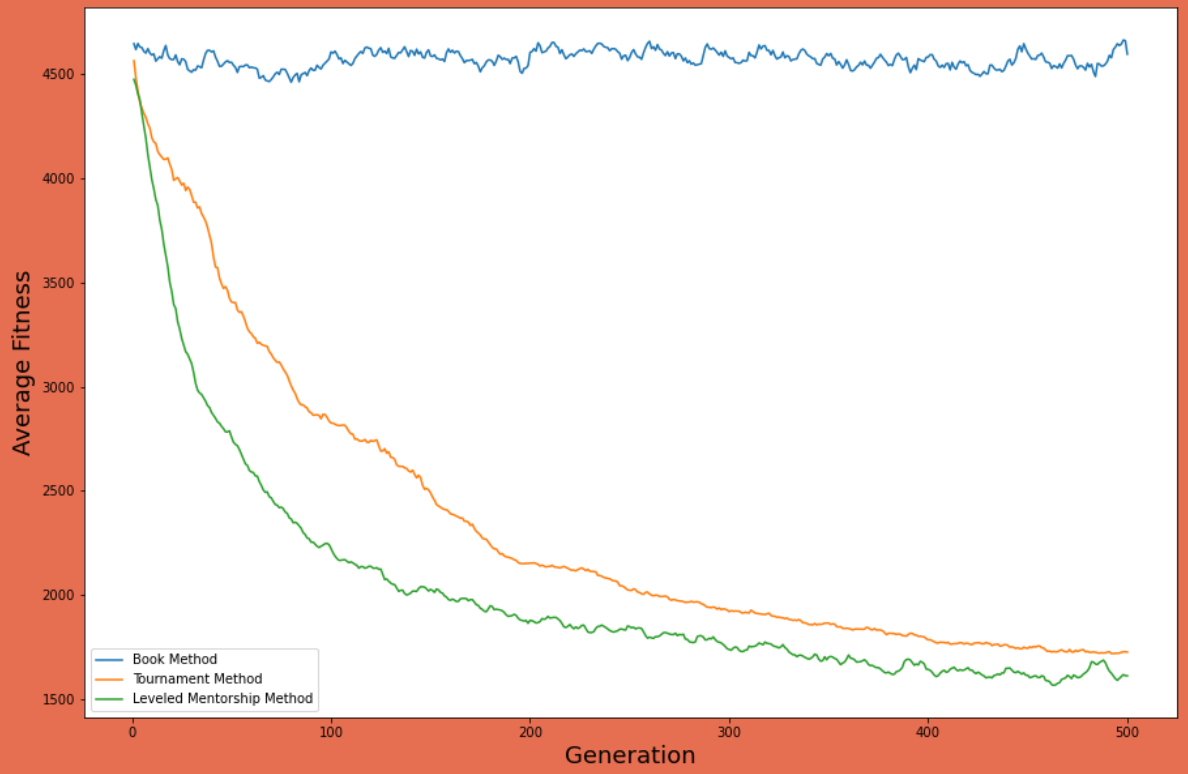
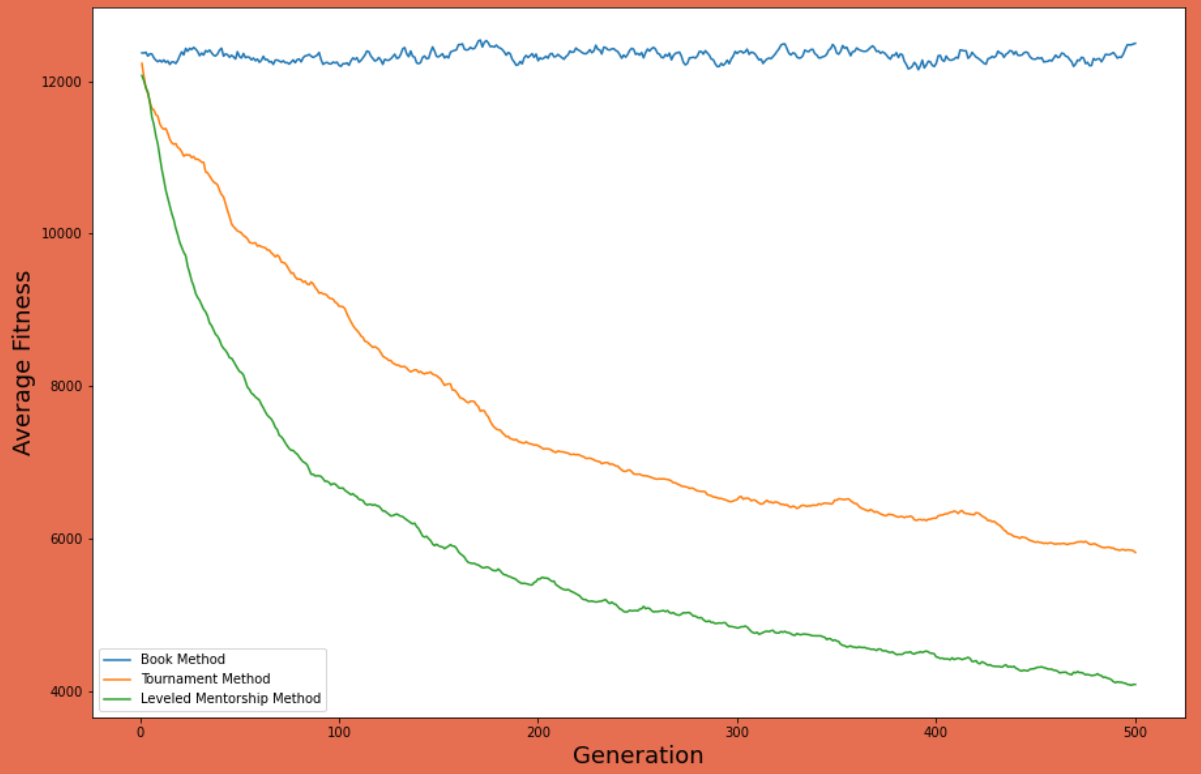
Average Fitness per Generation (TSP: xqf131)



Average Fitness per Generation (TSP: xqg237)



Results

Table 1: Evaluation Metrics of 3 Methods over 3 Iterations for xqf131 dataset
BF: Best Fitness, AF: Average Fitness, DS: Diversity Score

	Book			Tourn			Mentor		
	BF	AS	DF	BS	AS	DS	BS	AS	DS
1	3955	4515	284	1620	1658	202	1153	1320	79
2	4094	4632	283	1519	1563	74	1365	1488	66
3	3944	4597	281	1679	1724	180	1445	1610	113

Table 2: Evaluation Metrics of 3 Methods over 3 Iterations for xqg237 dataset
BF: Best Fitness, AF: Average Fitness, DS: Diversity Score

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CONCLUSION

This project aimed to provide a new approach to the selection of fit individuals to move on the next generation as well as make an intentional choice on parents for crossover while maintaining diversity.

The method was shown to perform better than the standard approach as well as a tournament selection approach but the diversity of the leveled mentorship method may need improvement.

THANK YOU!

Questions?