Solving Eternity II

An approach with Genetic Algorithms

FEUP / MIEIC
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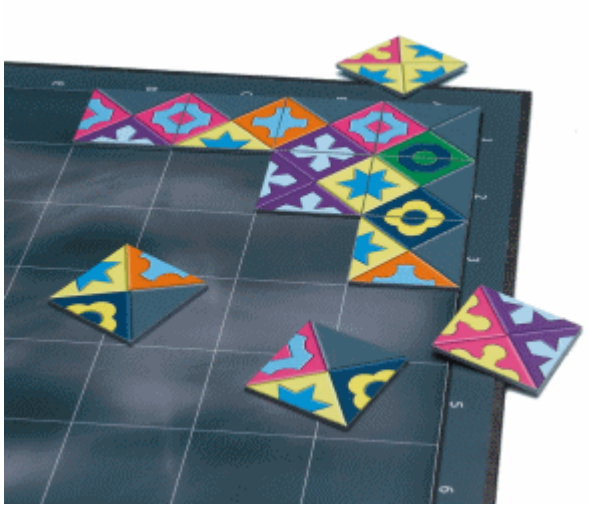
Summary

- Eternity II puzzle
- The problem
- Devised solution

Eternity II puzzle



Eternity II puzzle

- 16x16 board (256 pieces) 21 different patterns
- NP-Complete problem
- $256! * 4^{256} \approx 1.15x10^{661}$ solutions
  - Our approach will be directed to simpler versions of the puzzle

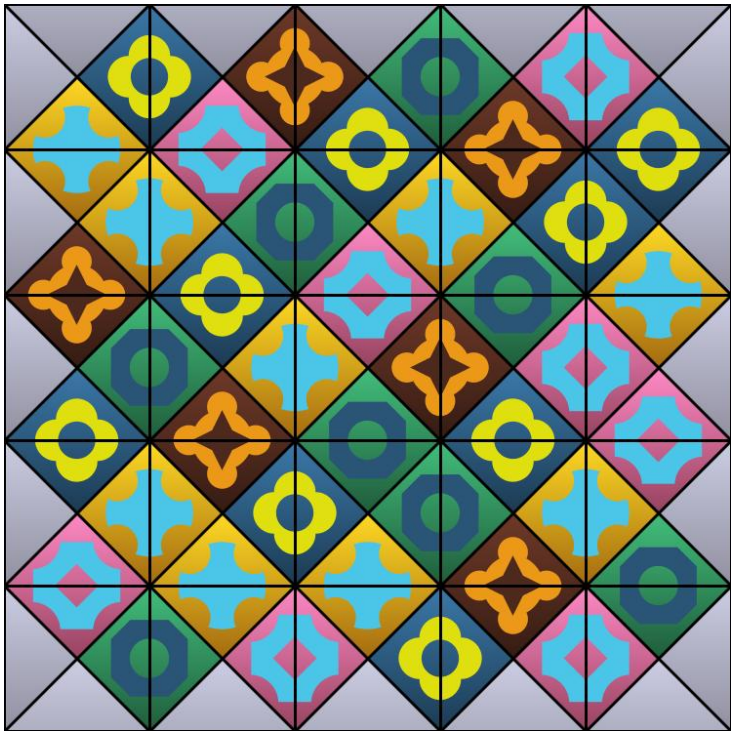
The problem

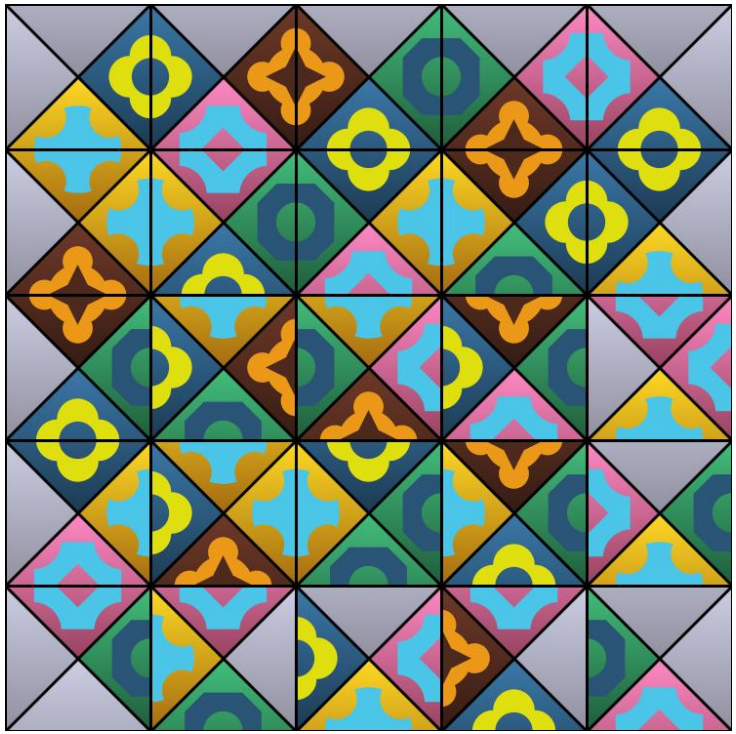
Context

- Very little work has been done in regards to Eternity II & Genetic Algorithms
- How can Eternity II be modeled as a Genetic Algorithm problem

The solution

Chromossome





The solution

Fitness function

$$fitness = \frac{n_matching_edges}{total_matching_edges}$$

The solution

Selection and breeding

- Elitist selection
  - Order the population by fitness, higher-to-lower, and keep the first half
- Stochastic breeding
  - Every selected individual has an equal chance of breeding with any other, creating two *children* boards
  - Next generation is composed of the selected *parents* and children resulting from the breeding

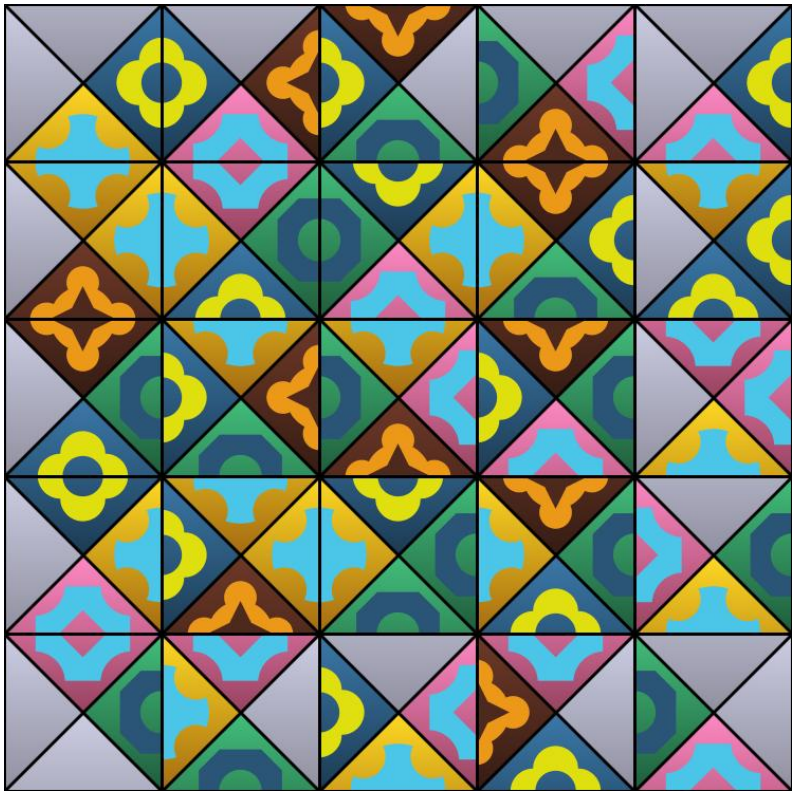
The solution

Crossover

- *Features* from each of the parent boards are extracted
- The best *feature* from parent A and a compatible *feature* from parent B are combined and vice-versa
- The remaining pieces (not present in any of the features) are then placed on the board using a simple constructive method

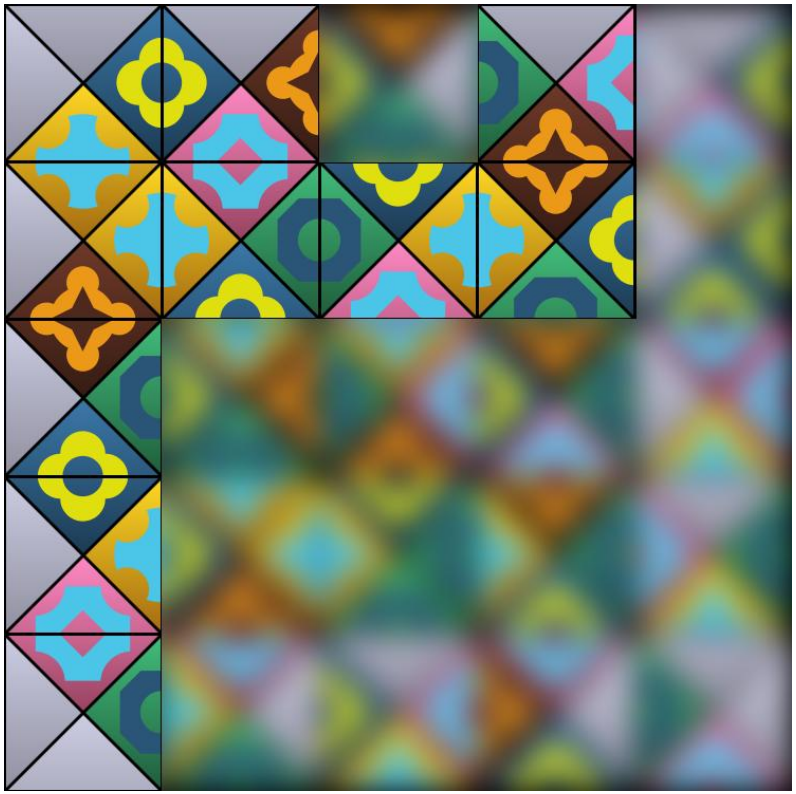
The solution

Crossover - features



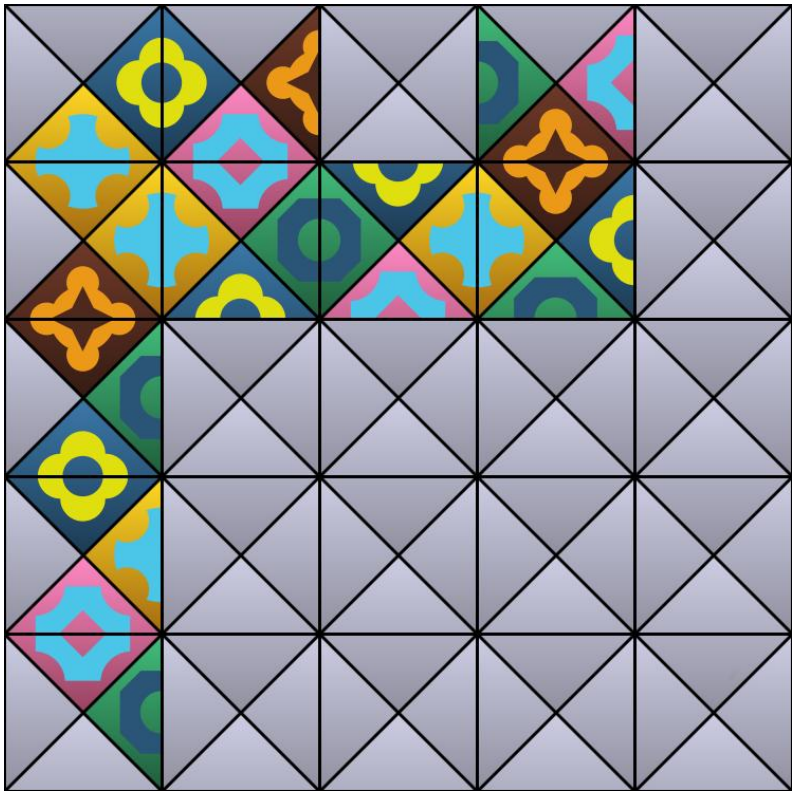
The solution

Crossover - features



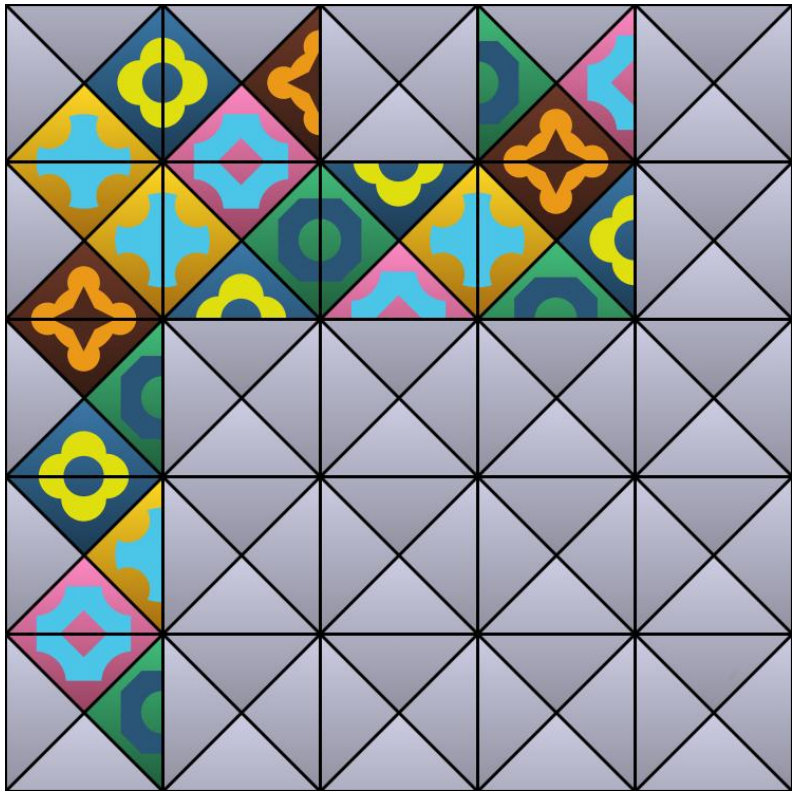
The solution

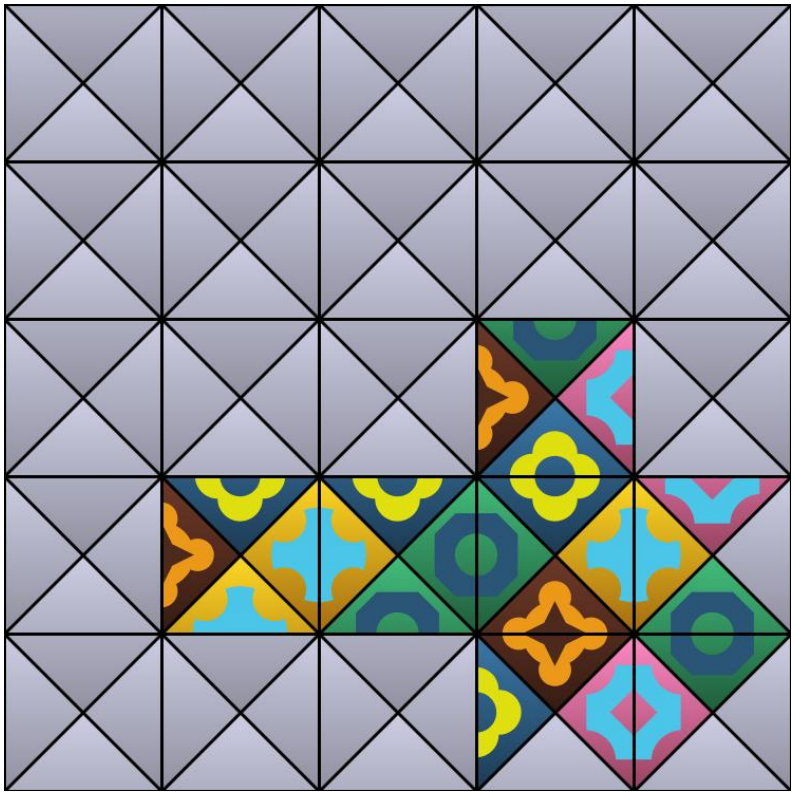
Crossover - features



The solution

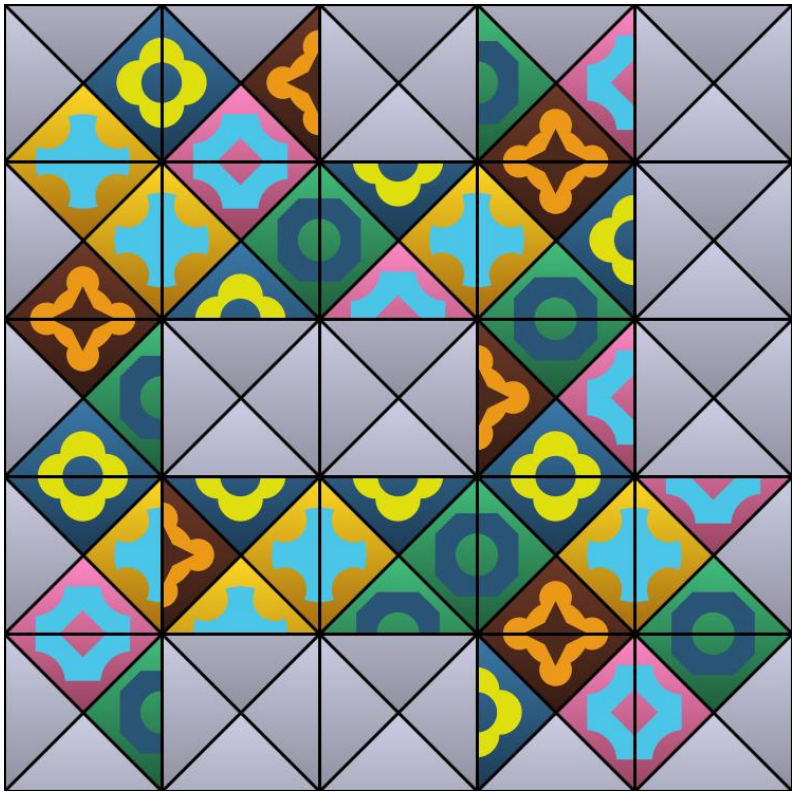
Crossover - features





The solution

Crossover - features



The solution

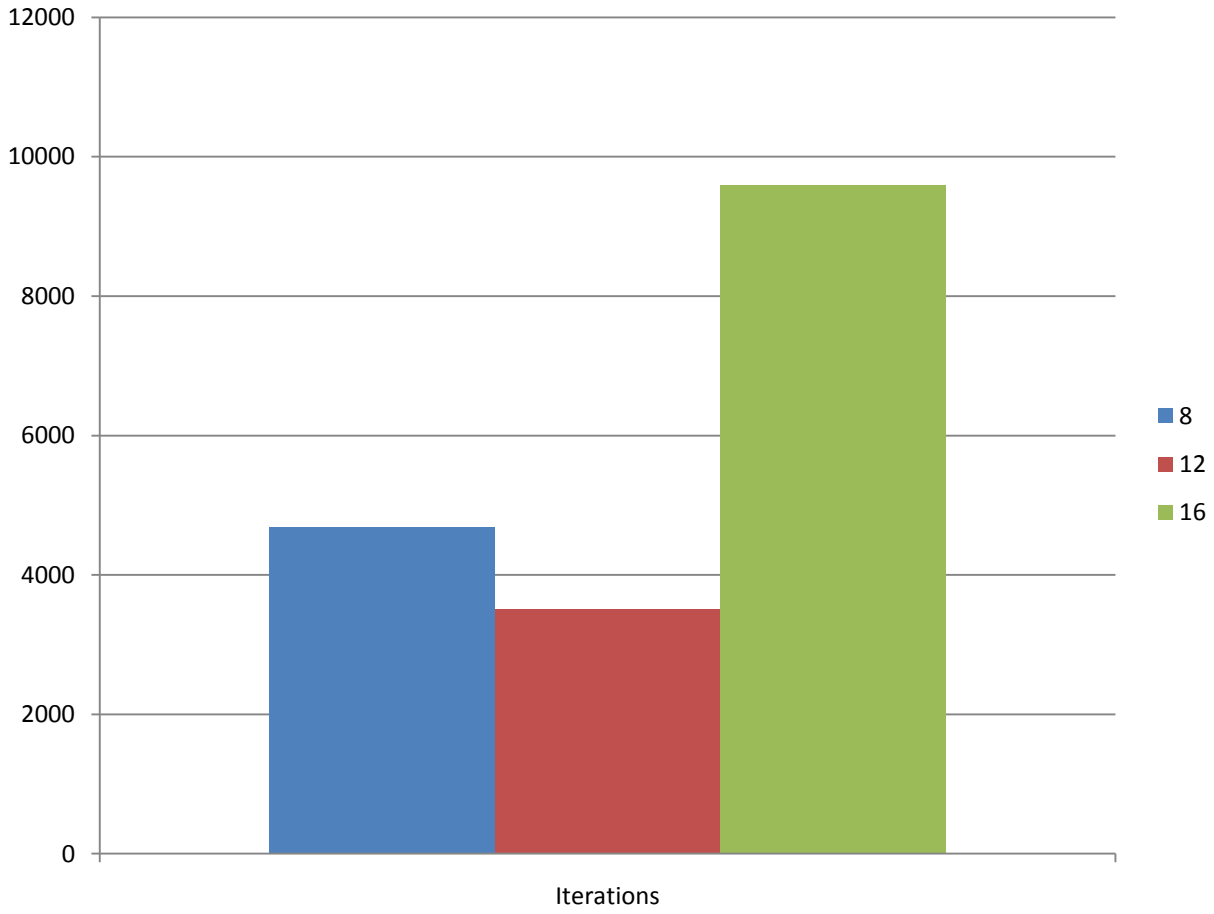
Mutations

- *n – 1* pieces are randomly selected from all the pieces in the board and rotated clockwise with a probability of 50%
- Once the board score reaches a certain threshold, all pieces are checked for rotation optimizations

Results

Population size

7x7, 6 patterns



Results

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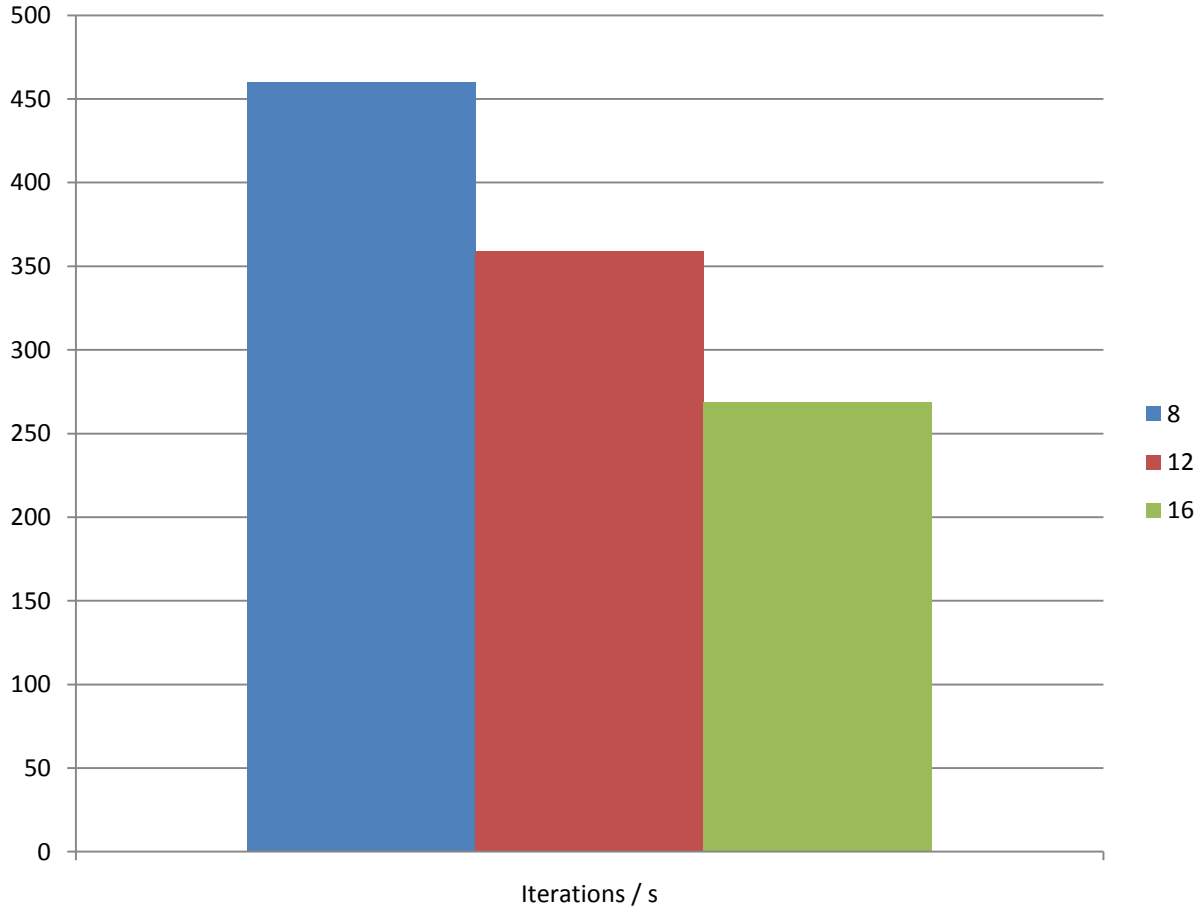

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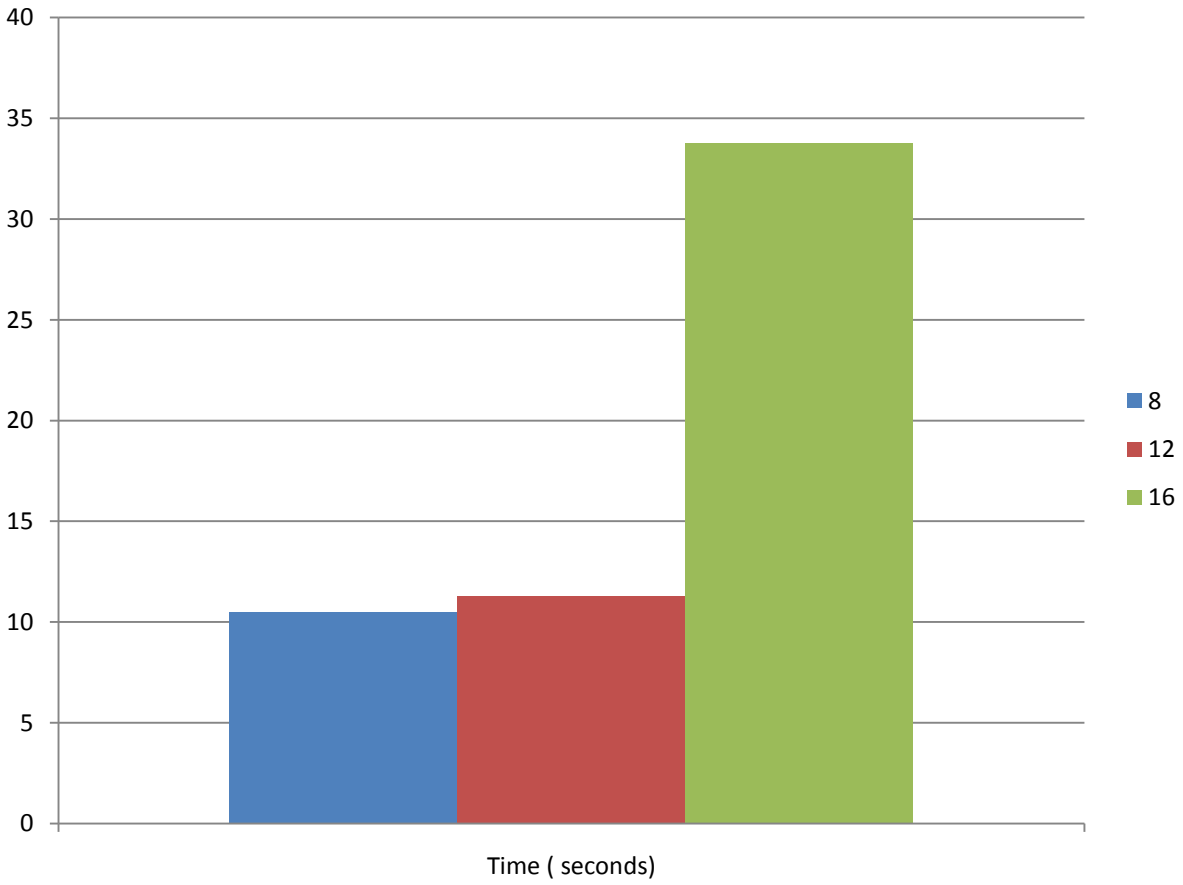
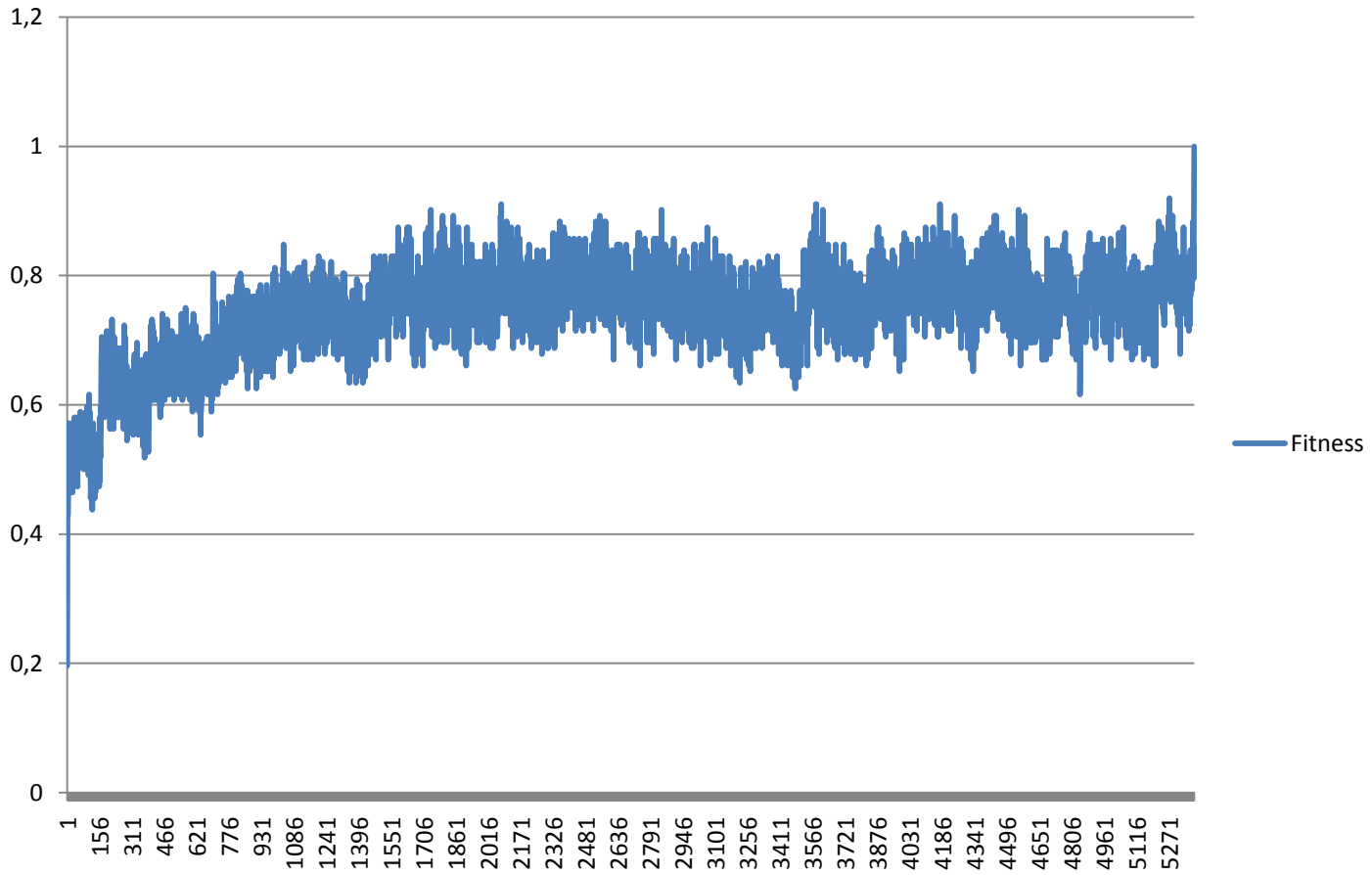


Results

Fitness evolution

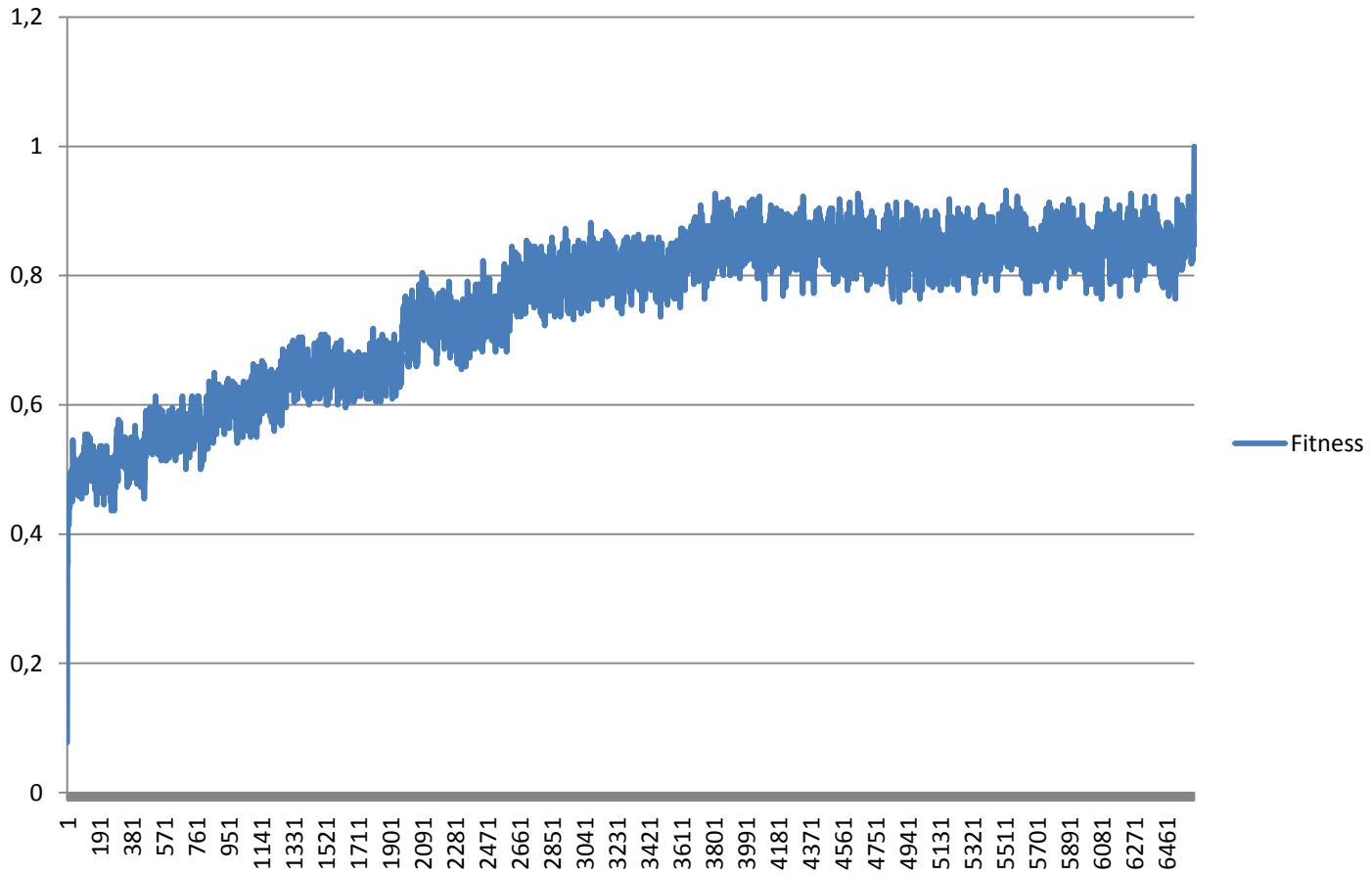
7x7



Results

Fitness evolution

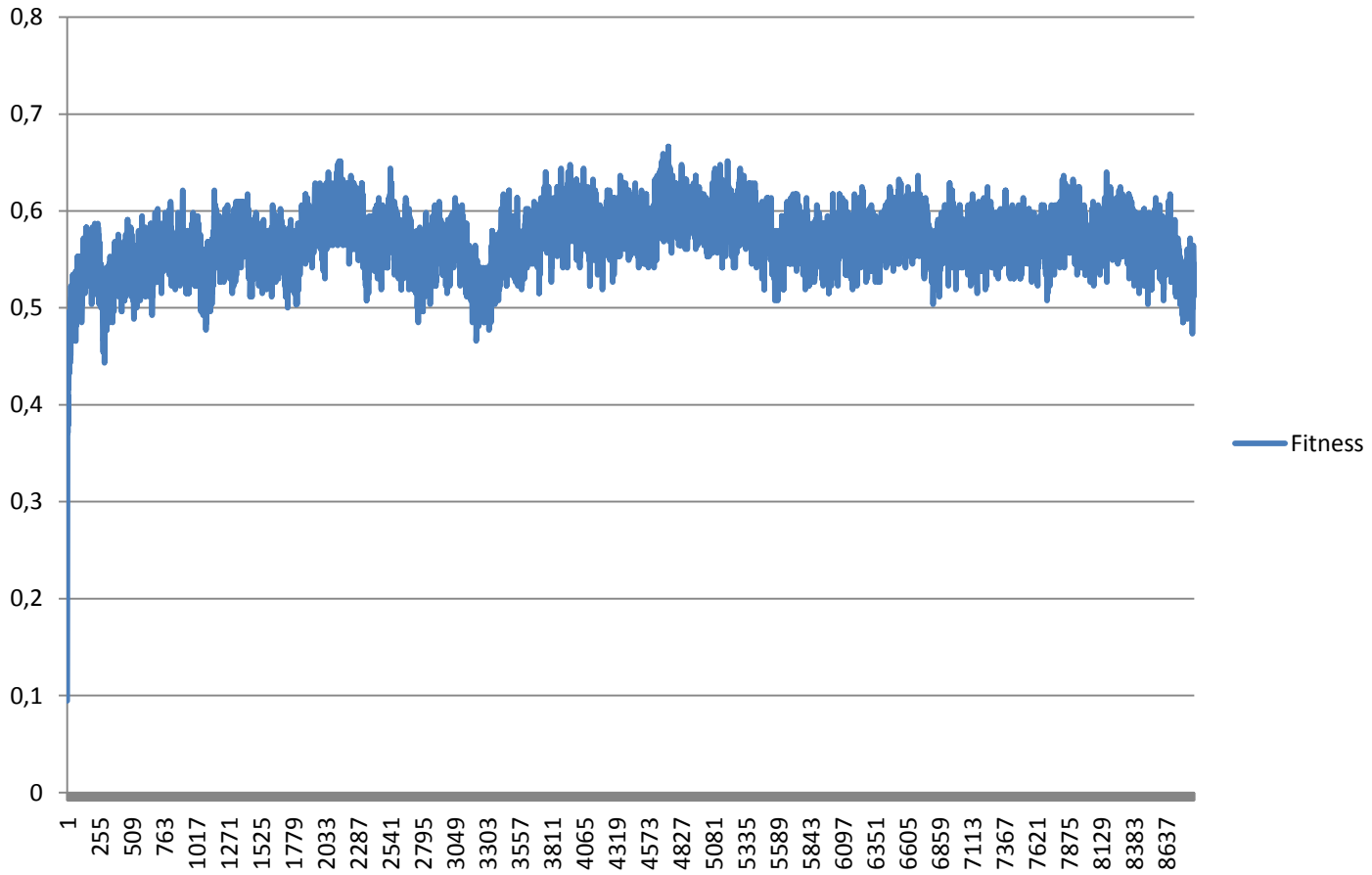
10x10



Results

Fitness evolution

11x11



Conclusions

- Genetic algorithms are more appropriate at optimizing problems then solving them
- We believe feature detection is appropriate for finding solutions to Eternity II
  - Perhaps better results could be achieved by using clusters of features instead of a single feature from each parent
- An appropriate data structure would greatly boost performance

Future Work

- Using better, more performant data structures
  - Index pieces in order to access them in O(1)
- Improve crossover and mutation strategies