FS2017

# Multi-Objective Evolutionary Algorithm

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COMP SCI 5401 FS2017 | ASSIGNMENT 1D

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# Overview of Algorithm

This report is analyzing the results of a multi-objective evolutionary algorithm for the offline 2D Bin Packing problem. This algorithm is trying to optimize the horizontal distance the shapes occupy on the sheet. The primary purpose for this is to minimize the amount of stock needed to cut each given shape. The other objective the algorithm is trying to optimize is the vertical distance. This is primarily to avoid having to use the entire vertical spread of the stock so as to eliminate the need to cut shapes from the imperfect edges of the sheet. These optimizations evolve by making Pareto improvements to the population. When the algorithm is completed, it returns the best Pareto optimal front found to the user to decide which solution is truly most fit.

# Overview of Experiment

This experiment runs the algorithm using three different configurations on three different problem sets. These results are then analyzed to compare diversity as well as best achieved value for each of the objectives. The configuration differences are as follows:

- Configuration 1
    - Standard starting point to compare other two configurations to
- Configuration 2
    - Significant increase in population size and number of children spawned in each generation (4x)
- Configuration 3
    - Significant increase in mutation rate (3x)

The exact configuration files can be found in the “configuration files” portion of this report. Each of these configurations were run for each problem set, and then the results of each problem instance where then analyzed against each other to see if these changes made a statistical difference and if so which configuration yielded better results. The results of this experiment follow.

# Configuration 1

## Data

50 Shapes

100 Shapes

100 Complex Shapes

## Analysis

50 Shapes

100 Shapes

100 Complex Shapes

# Configuration 2

## Data

### 50 Shapes

### 100 Shapes

### 100 Complex Shapes

## Analysis

### 50 Shapes

### 100 Shapes

### 100 Complex Shapes

# Configuration 3

## Data

### 50 Shapes

### 100 Shapes

### 100 Complex Shapes

## Analysis

### 50 Shapes

### 100 Shapes

### 100 Complex Shapes

# Configuration Files

## 50 Shapes

### Configuration 1

```
<?xml version="1.0"?>
<config>
  <searchType dataType="String" >EvolutionarySearch</searchType>
  <seedSpecified dataType="Boolean" >false</seedSpecified>
  <fitnessEvals dataType="Integer" >10000</fitnessEvals>
  <runs dataType="Integer" >30</runs>
  <logFilePath dataType="String" >./log/1d/50Shapes/config1.txt</logFilePath>
  <solFilePath dataType="String" >./sol/1d/50Shapes/config1.txt</solFilePath>

  <showShapes dataType="Boolean">true</showShapes>
  <showConfig dataType="Boolean">true</showConfig>

  <!-- Evolutionary Parameters-->
  <populationSize dataType="Integer">75</populationSize>
  <numChildren dataType="Integer">25</numChildren>
  <mutationRate dataType="Double">0.25</mutationRate>
  <convergenceCriterion dataType="Integer">15</convergenceCriterion>

  <parentSelectionMethod dataType="String">kTournament</parentSelectionMethod>
  <parentSelectionTournamentSize dataType="Integer">4</parentSelectionTournamentSize>
  <parentsPerChild dataType="Integer">5</parentsPerChild>

  <survivorSelectionMethod dataType="String">kTournament</survivorSelectionMethod>
  <survivorSelectionTournamentSize
dataType="Integer">4</survivorSelectionTournamentSize>
  <multiaryOperator dataType="String">nPointCrossover</multiaryOperator>
  <numCrossoverPoints dataType="Integer">1</numCrossoverPoints>

  <!-- Assignment 1C Configurations -->
  <constraintSatisfaction dataType="String">repair</constraintSatisfaction>
  <penaltyCoefficient dataType="Double">0.33</penaltyCoefficient>

  <survivalStrategy dataType="String">Plus</survivalStrategy>

  <selfAdaptiveMutationRate dataType="Boolean">false</selfAdaptiveMutationRate>

</config>
```

### Configuration 2

```
<?xml version="1.0"?>
<config>
  <searchType dataType="String" >EvolutionarySearch</searchType>
  <seedSpecified dataType="Boolean" >false</seedSpecified>
  <fitnessEvals dataType="Integer" >10000</fitnessEvals>
  <runs dataType="Integer" >30</runs>
```

```
  <logFilePath dataType="String" >./log/1d/50Shapes/config2.txt</logFilePath>
  <solFilePath dataType="String" >./sol/1d/50Shapes/config2.txt</solFilePath>

  <showShapes dataType="Boolean">true</showShapes>
  <showConfig dataType="Boolean">true</showConfig>

  <!-- Evolutionary Parameters-->
  <populationSize dataType="Integer">200</populationSize>
  <numChildren dataType="Integer">100</numChildren>
  <mutationRate dataType="Double">0.25</mutationRate>
  <convergenceCriterion dataType="Integer">15</convergenceCriterion>

  <parentSelectionMethod dataType="String">kTournament</parentSelectionMethod>
  <parentSelectionTournamentSize dataType="Integer">4</parentSelectionTournamentSize>
  <parentsPerChild dataType="Integer">5</parentsPerChild>

  <survivorSelectionMethod dataType="String">kTournament</survivorSelectionMethod>
  <survivorSelectionTournamentSize
dataType="Integer">4</survivorSelectionTournamentSize>
  <multiaryOperator dataType="String">nPointCrossover</multiaryOperator>
  <numCrossoverPoints dataType="Integer">1</numCrossoverPoints>

  <!-- Assignment 1C Configurations -->
  <constraintSatisfaction dataType="String">repair</constraintSatisfaction>
  <penaltyCoefficient dataType="Double">0.33</penaltyCoefficient>

  <survivalStrategy dataType="String">Plus</survivalStrategy>

  <selfAdaptiveMutationRate dataType="Boolean">false</selfAdaptiveMutationRate>
</config>
```

## Configuration 3

```
<?xml version="1.0"?>
<config>
  <searchType dataType="String" >EvolutionarySearch</searchType>
  <seedSpecified dataType="Boolean" >false</seedSpecified>
  <fitnessEvals dataType="Integer" >10000</fitnessEvals>
  <runs dataType="Integer" >30</runs>
  <logFilePath dataType="String" >./log/1d/50Shapes/config3.txt</logFilePath>
  <solFilePath dataType="String" >./sol/1d/50Shapes/config3.txt</solFilePath>

  <showShapes dataType="Boolean">true</showShapes>
  <showConfig dataType="Boolean">true</showConfig>

  <!-- Evolutionary Parameters-->
  <populationSize dataType="Integer">75</populationSize>
  <numChildren dataType="Integer">25</numChildren>
  <mutationRate dataType="Double">0.75</mutationRate>
  <convergenceCriterion dataType="Integer">15</convergenceCriterion>

  <parentSelectionMethod dataType="String">kTournament</parentSelectionMethod>
  <parentSelectionTournamentSize dataType="Integer">4</parentSelectionTournamentSize>
  <parentsPerChild dataType="Integer">5</parentsPerChild>

  <survivorSelectionMethod dataType="String">kTournament</survivorSelectionMethod>
  <survivorSelectionTournamentSize
dataType="Integer">4</survivorSelectionTournamentSize>
  <multiaryOperator dataType="String">nPointCrossover</multiaryOperator>
```

```
  <numCrossoverPoints dataType="Integer">1</numCrossoverPoints>

  <!-- Assignment 1C Configurations -->
  <constraintSatisfaction dataType="String">repair</constraintSatisfaction>
  <penaltyCoefficient dataType="Double">0.33</penaltyCoefficient>

  <survivalStrategy dataType="String">Plus</survivalStrategy>

  <selfAdaptiveMutationRate dataType="Boolean">false</selfAdaptiveMutationRate>


</config>
```

# 100 Shapes

## Configuration 1

```
<?xml version="1.0"?>
<config>
  <searchType dataType="String" >EvolutionarySearch</searchType>
  <seedSpecified dataType="Boolean" >false</seedSpecified>
  <fitnessEvals dataType="Integer" >10000</fitnessEvals>
  <runs dataType="Integer" >30</runs>
  <logFilePath dataType="String" >./log/1d/100Shapes/config1.txt</logFilePath>
  <solFilePath dataType="String" >./sol/1d/100Shapes/config1.txt</solFilePath>

  <showShapes dataType="Boolean">true</showShapes>
  <showConfig dataType="Boolean">true</showConfig>

  <!-- Evolutionary Parameters-->
  <populationSize dataType="Integer">75</populationSize>
  <numChildren dataType="Integer">25</numChildren>
  <mutationRate dataType="Double">0.25</mutationRate>
  <convergenceCriterion dataType="Integer">15</convergenceCriterion>

  <parentSelectionMethod dataType="String">kTournament</parentSelectionMethod>
  <parentSelectionTournamentSize dataType="Integer">4</parentSelectionTournamentSize>
  <parentsPerChild dataType="Integer">5</parentsPerChild>

  <survivorSelectionMethod dataType="String">kTournament</survivorSelectionMethod>
  <survivorSelectionTournamentSize
dataType="Integer">4</survivorSelectionTournamentSize>
  <multiaryOperator dataType="String">nPointCrossover</multiaryOperator>
  <numCrossoverPoints dataType="Integer">1</numCrossoverPoints>

  <!-- Assignment 1C Configurations -->
  <constraintSatisfaction dataType="String">repair</constraintSatisfaction>
  <penaltyCoefficient dataType="Double">0.33</penaltyCoefficient>

  <survivalStrategy dataType="String">Plus</survivalStrategy>

  <selfAdaptiveMutationRate dataType="Boolean">false</selfAdaptiveMutationRate>
```

```
</config>
```

## Configuration 2

```
<?xml version="1.0"?>
<config>
  <searchType dataType="String" >EvolutionarySearch</searchType>
  <seedSpecified dataType="Boolean" >false</seedSpecified>
  <fitnessEvals dataType="Integer" >10000</fitnessEvals>
  <runs dataType="Integer" >30</runs>
  <logFilePath dataType="String" >./log/1d/100Shapes/config2.txt</logFilePath>
  <solFilePath dataType="String" >./sol/1d/100Shapes/config2.txt</solFilePath>

  <showShapes dataType="Boolean">true</showShapes>
  <showConfig dataType="Boolean">true</showConfig>

  <!-- Evolutionary Parameters-->
  <populationSize dataType="Integer">200</populationSize>
  <numChildren dataType="Integer">100</numChildren>
  <mutationRate dataType="Double">0.25</mutationRate>
  <convergenceCriterion dataType="Integer">15</convergenceCriterion>

  <parentSelectionMethod dataType="String">kTournament</parentSelectionMethod>
  <parentSelectionTournamentSize dataType="Integer">4</parentSelectionTournamentSize>
  <parentsPerChild dataType="Integer">5</parentsPerChild>

  <survivorSelectionMethod dataType="String">kTournament</survivorSelectionMethod>
  <survivorSelectionTournamentSize
dataType="Integer">4</survivorSelectionTournamentSize>
  <multiaryOperator dataType="String">nPointCrossover</multiaryOperator>
  <numCrossoverPoints dataType="Integer">1</numCrossoverPoints>

  <!-- Assignment 1C Configurations -->
  <constraintSatisfaction dataType="String">repair</constraintSatisfaction>
  <penaltyCoefficient dataType="Double">0.33</penaltyCoefficient>

  <survivalStrategy dataType="String">Plus</survivalStrategy>

  <selfAdaptiveMutationRate dataType="Boolean">false</selfAdaptiveMutationRate>



</config>
```

## Configuration 3

```
<?xml version="1.0"?>
<config>
  <searchType dataType="String" >EvolutionarySearch</searchType>
  <seedSpecified dataType="Boolean" >false</seedSpecified>
  <fitnessEvals dataType="Integer" >10000</fitnessEvals>
  <runs dataType="Integer" >30</runs>
```

```
  <logFilePath dataType="String" >./log/1d/100Shapes/config3.txt</logFilePath>
  <solFilePath dataType="String" >./sol/1d/100Shapes/config3.txt</solFilePath>

  <showShapes dataType="Boolean">true</showShapes>
  <showConfig dataType="Boolean">true</showConfig>

  <!-- Evolutionary Parameters-->
  <populationSize dataType="Integer">75</populationSize>
  <numChildren dataType="Integer">25</numChildren>
  <mutationRate dataType="Double">0.75</mutationRate>
  <convergenceCriterion dataType="Integer">15</convergenceCriterion>

  <parentSelectionMethod dataType="String">kTournament</parentSelectionMethod>
  <parentSelectionTournamentSize dataType="Integer">4</parentSelectionTournamentSize>
  <parentsPerChild dataType="Integer">5</parentsPerChild>

  <survivorSelectionMethod dataType="String">kTournament</survivorSelectionMethod>
  <survivorSelectionTournamentSize
dataType="Integer">4</survivorSelectionTournamentSize>
  <multiaryOperator dataType="String">nPointCrossover</multiaryOperator>
  <numCrossoverPoints dataType="Integer">1</numCrossoverPoints>

  <!-- Assignment 1C Configurations -->
  <constraintSatisfaction dataType="String">repair</constraintSatisfaction>
  <penaltyCoefficient dataType="Double">0.33</penaltyCoefficient>

  <survivalStrategy dataType="String">Plus</survivalStrategy>

  <selfAdaptiveMutationRate dataType="Boolean">false</selfAdaptiveMutationRate>



</config>
```

# 100 Complex Shapes

## Configuration 1

```
<?xml version="1.0"?>
<config>
  <searchType dataType="String" >EvolutionarySearch</searchType>
  <seedSpecified dataType="Boolean" >false</seedSpecified>
  <fitnessEvals dataType="Integer" >10000</fitnessEvals>
  <runs dataType="Integer" >30</runs>
  <logFilePath dataType="String" >./log/1d/100ComplexShapes/config1.txt</logFilePath>
  <solFilePath dataType="String" >./sol/1d/100ComplexShapes/config1.txt</solFilePath>

  <showShapes dataType="Boolean">true</showShapes>
  <showConfig dataType="Boolean">true</showConfig>

  <!-- Evolutionary Parameters-->
  <populationSize dataType="Integer">75</populationSize>
  <numChildren dataType="Integer">25</numChildren>
  <mutationRate dataType="Double">0.25</mutationRate>
  <convergenceCriterion dataType="Integer">15</convergenceCriterion>
```

```
  <parentSelectionMethod dataType="String">kTournament</parentSelectionMethod>
  <parentSelectionTournamentSize dataType="Integer">4</parentSelectionTournamentSize>
  <parentsPerChild dataType="Integer">5</parentsPerChild>

  <survivorSelectionMethod dataType="String">kTournament</survivorSelectionMethod>
  <survivorSelectionTournamentSize
dataType="Integer">4</survivorSelectionTournamentSize>
  <multiaryOperator dataType="String">nPointCrossover</multiaryOperator>
  <numCrossoverPoints dataType="Integer">1</numCrossoverPoints>

  <!-- Assignment 1C Configurations -->
  <constraintSatisfaction dataType="String">repair</constraintSatisfaction>
  <penaltyCoefficient dataType="Double">0.33</penaltyCoefficient>

  <survivalStrategy dataType="String">Plus</survivalStrategy>

  <selfAdaptiveMutationRate dataType="Boolean">false</selfAdaptiveMutationRate>


</config>
```

## Configuration 2

```
<?xml version="1.0"?>
<config>
  <searchType dataType="String" >EvolutionarySearch</searchType>
  <seedSpecified dataType="Boolean" >false</seedSpecified>
  <fitnessEvals dataType="Integer" >10000</fitnessEvals>
  <runs dataType="Integer" >30</runs>
  <logFilePath dataType="String" >./log/1d/100ComplexShapes/config2.txt</logFilePath>
  <solFilePath dataType="String" >./sol/1d/100ComplexShapes/config2.txt</solFilePath>

  <showShapes dataType="Boolean">true</showShapes>
  <showConfig dataType="Boolean">true</showConfig>

  <!-- Evolutionary Parameters-->
  <populationSize dataType="Integer">75</populationSize>
  <numChildren dataType="Integer">25</numChildren>
  <mutationRate dataType="Double">0.25</mutationRate>
  <convergenceCriterion dataType="Integer">15</convergenceCriterion>

  <parentSelectionMethod dataType="String">kTournament</parentSelectionMethod>
  <parentSelectionTournamentSize dataType="Integer">8</parentSelectionTournamentSize>
  <parentsPerChild dataType="Integer">5</parentsPerChild>

  <survivorSelectionMethod dataType="String">kTournament</survivorSelectionMethod>
  <survivorSelectionTournamentSize
dataType="Integer">8</survivorSelectionTournamentSize>
  <multiaryOperator dataType="String">nPointCrossover</multiaryOperator>
  <numCrossoverPoints dataType="Integer">1</numCrossoverPoints>

  <!-- Assignment 1C Configurations -->
  <constraintSatisfaction dataType="String">repair</constraintSatisfaction>
  <penaltyCoefficient dataType="Double">0.33</penaltyCoefficient>

  <survivalStrategy dataType="String">Plus</survivalStrategy>

  <selfAdaptiveMutationRate dataType="Boolean">false</selfAdaptiveMutationRate>
```

```
</config>
```

## Configuration 3

```
<?xml version="1.0"?>
<config>
  <searchType dataType="String" >EvolutionarySearch</searchType>
  <seedSpecified dataType="Boolean" >false</seedSpecified>
  <fitnessEvals dataType="Integer" >10000</fitnessEvals>
  <runs dataType="Integer" >30</runs>
  <logFilePath dataType="String" >./log/1d/100ComplexShapes/config3.txt</logFilePath>
  <solFilePath dataType="String" >./sol/1d/100ComplexShapes/config3.txt</solFilePath>

  <showShapes dataType="Boolean">true</showShapes>
  <showConfig dataType="Boolean">true</showConfig>

  <!-- Evolutionary Parameters-->
  <populationSize dataType="Integer">75</populationSize>
  <numChildren dataType="Integer">25</numChildren>
  <mutationRate dataType="Double">0.75</mutationRate>
  <convergenceCriterion dataType="Integer">15</convergenceCriterion>

  <parentSelectionMethod dataType="String">kTournament</parentSelectionMethod>
  <parentSelectionTournamentSize dataType="Integer">4</parentSelectionTournamentSize>
  <parentsPerChild dataType="Integer">5</parentsPerChild>

  <survivorSelectionMethod dataType="String">kTournament</survivorSelectionMethod>
  <survivorSelectionTournamentSize
dataType="Integer">4</survivorSelectionTournamentSize>
  <multiaryOperator dataType="String">nPointCrossover</multiaryOperator>
  <numCrossoverPoints dataType="Integer">1</numCrossoverPoints>

  <!-- Assignment 1C Configurations -->
  <constraintSatisfaction dataType="String">repair</constraintSatisfaction>
  <penaltyCoefficient dataType="Double">0.33</penaltyCoefficient>

  <survivalStrategy dataType="String">Plus</survivalStrategy>

  <selfAdaptiveMutationRate dataType="Boolean">false</selfAdaptiveMutationRate>



</config>
```

# Log and Solution Files