Assignment 1

Due date: September 29, 2011
Type your answers and submit a printed hard copy.
Hand-written solutions are not accepted.

1 Problem Modeling

Your task is to frame the problem for an evolutionary algorithm to search for a solution. For each question, provide the following with explanation: variables (2 marks), representation (3 marks), constraints if any (2 marks), fitness function (3 marks). Note that there are more than one way to frame a problem; some representations produce smoother fitness landscapes, hence are easier for an evolutionary algorithm to search for a solution, than others. Trust your own instinct and create your own solution.

1.1 Capital Budgeting (10 marks)

There are four proposed projects, each of which runs for 3 years and has the following characteristics.

<table>
<thead>
<tr>
<th>Project</th>
<th>Return (million)</th>
<th>Capital Required (million)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>year 1</td>
<td>year 2</td>
</tr>
<tr>
<td>1</td>
<td>0.2</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>0.3</td>
<td>1.0</td>
</tr>
<tr>
<td>3</td>
<td>0.5</td>
<td>1.5</td>
</tr>
<tr>
<td>4</td>
<td>0.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>

The available budget is 3.1 millions for year 1, 2.5 millions for year 2 and 0.4 million for your 3. The problem is to decide which projects to invest in order to maximize the total return.

1.2 Tournament Scheduling (10 marks)

There are 12 school teams, unimaginatively named A, B, C, D, E, F, G, H, I, J, K, and L. They must play one another on 11 consecutive days on six fields.
Every team must play every other team exactly once. Each team plays one
game per day. The problem is to provide a schedule for this tournament.

1.3 Sudoku (10 marks)

Skudo is a number placement puzzle. The objective is to fill a 9 by 9 grid
with digits between 1 and 9. Each digit should appear exactly once in each
row, once in each column, and once in each non-overlapping three by three
box starting from the upper left corner. The problem is to solve the following
Sudoku puzzle.

```
  7  4  8  9  3
  6  8  2
  7  5  2  8  6
  8  6  7  1
  9  3  4  8
  7  4  9
  6  9
  4  5  9  1  8
```

2 Computer Exercises

2.1 Generational Selection-only Model (25 marks)

Implement a generational evolutionary algorithm with population size of 50
and assign each individual with a unique fitness between 0 and 100. One way
to implement this is using the fitness value to represent the individual. Next,
apply each of the following selection methods to create a new population for
50 generations.

- Random selection
- Fitness-proportionate selection
- Binary-tournament selection
- Linear-ranking selection
- Truncation selection (top 50%)
For each selection method, make 20 runs. During each run, collect average population fitness, best individual fitness and the number of unique genotype in the population at each generation. Next, calculate the mean and standard error. Finally, produce the following 3 figures by plotting the mean and standard error of the required data generated from the 5 selection methods:

- **(6 marks)** The average population fitness at each generation.
- **(6 marks)** The best individual fitness at each generation.
- **(6 marks)** The number of unique genotype in the population (diversity) at each generation.

**(7 marks)** Discuss the following evolutionary behaviors based on your data.

- Does the selection method which produce a higher population average fitness also produce a higher population best fitness? Why or why not?

- The relationship between population diversity and the population best and average fitness improvement.

### 2.2 Steady-state Selection-only Model (25 marks)

In this exercise, you will choose 2 of the 4 fitness-based (non-random) selection methods from exercise 2.1 to conduct your experiments. First, initialize your population of 100 individuals using the same method as that in exercise 2.1. Next, select individual one at a time using the fitness-based method to replaced one random member in the population. Every 100 replacements is equivalent to 1 generation. Do this for 50 generations.

Collect your experimental data and produce the same 3 figures as that in exercise 2.1 **(6 marks each)**. However, you will compare the data generated from the generational model with that from the steady-state model. Since you have 2 fitness-based selection methods, each figure contains 4 plots, 2 from the generational and 2 from the steady-state models. Finally, you will give some discussion about your observation of the similarities and differences in evolution behavior of the two population models, in terms of average population fitness improvement, best individual fitness improvement and population diversity **(7 marks)**.
2.3 Population Size (20 marks)

In this exercise, you will choose 1 of the 4 fitness-based (non-random) selection methods and either generational or steady-state models from exercise 2.1 or 2.2 to conduct your experiments. You will vary the population size of 10, 40 and 100 to make 20 runs each. Meanwhile, you will collect the data to produce the 3 figures described in exercise 2.1 (5 marks each). Since you have 3 population sizes, each figure contains 3 plots. Finally, you will give some discussion about your observation of the evolution behavior under different population size, in terms of average population fitness improvement, best individual fitness improvement and population diversity (5 marks).