Ludic Computing Course CO345  

Tutorial 1  

Evolutionary Design  

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Question 1  

1. What tree and program fragment would you get if you randomly generated a tree in the following way:  
   a. start with an X  
   b. replace it with X*Y  
   c. replace the Y with sin(X)  
   d. replace the most recent X with X+Y  
   e. replace the Y with the entire tree so far
Questions 2 and 3

Suppose you have 7 individuals in a population, with the following fitness calculations:
\( f(i_1) = 20, f(i_2) = 10, f(i_3) = 5, f(i_4) = 8, f(i_5) = 1, f(i_6) = 17, f(i_7) = 3 \)

2. Write down a plausible intermediate population. Justify your answer

3. What would be the nature of the only tournament that individual \( i_7 \) would be selected from?
Answers 2 and 3

1. We first need to calculate the average fitness, which is: \[(20 + 10 + 5 + 8 + 1 + 17 + 3)/7 = 9.14\]

Then we have to work out \(f(i)/9.14\) for each \(j\) and work out how many guaranteed IP entries each individual has, and what the probability \(P\) of gaining another one is.

\[f(i)/9.14 = 20/9.14 = 2.18 = 2\] guaranteed, \(P = 0.18\), 2 in IP is plausible

\[f(i2)/9.14 = 10/9.14 = 1.09 = 1\] guaranteed, \(P = 0.09\), 1 in IP is plausible

\[f(i3)/9.14 = 5/9.14 = 0.55 = 0\] guaranteed, \(P = 0.55\), 1 in IP is plausible

\[f(i4)/9.14 = 8/9.14 = 0.86 = 1\] guaranteed, \(P = 0.86\), 1 in IP is plausible

\[f(i5)/9.14 = 1/9.14 = 0.11 = 0\] guaranteed, \(P = 0.11\), 0 in IP is plausible

\[f(i6)/9.14 = 17/9.14 = 1.86 = 2\] guaranteed, \(P = 0.86\), 2 in IP is plausible

\[f(i7)/9.14 = 3/9.14 = 0.33 = 0\] guaranteed, \(P = 0.33\), 0 in IP is plausible

Hence, a plausible IP is: \{ \(i1, i1, i2, i3, i4, i6, i6\) \}

2. \(i7\) is only fitter than \(i5\), so the tournament would have to be for two individuals, with \(i7\) competing against \(i5\)

Questions 4, 5 and 6

4. Which of the individuals, \(U, V\) or \(W\) achieves the correct input/output pairings for the given program? Justify your answer.

Which parameter could be mutated without any change to the program I/O?

```java
public float tutorial(int x, int y){
    if (x < A * y) return x + y;
    else if (y < 10 * Math.sqrt(x)) {
        return y + Math.abs(x - B);
    }
    else return C * x;
}
```

5. Perform 1-point crossover on individuals \(V\) and \(W\) to generate a program which outputs a different value for input \((17,17)\) than both its parents

6. Draw the body of the program with parameters \(U\) in a suitable tree representation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A)</td>
<td>0</td>
</tr>
<tr>
<td>(B)</td>
<td>3</td>
</tr>
<tr>
<td>(C)</td>
<td>5</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A)</td>
<td>1</td>
</tr>
<tr>
<td>(B)</td>
<td>2</td>
</tr>
<tr>
<td>(C)</td>
<td>3</td>
</tr>
</tbody>
</table>

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<thead>
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<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A)</td>
<td>2</td>
</tr>
<tr>
<td>(B)</td>
<td>10</td>
</tr>
<tr>
<td>(C)</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>((9,8))</td>
<td>17</td>
</tr>
<tr>
<td>((1,2))</td>
<td>3</td>
</tr>
<tr>
<td>((16,2))</td>
<td>8</td>
</tr>
</tbody>
</table>
Answer 4

```java
public float tutorial(int x, int y){
    if (x < 0 * y) return x + y;
    else if (y < 10 * Math.sqrt(x)) {
        return y + Math.abs(x - 3);
    }
    else return 5 * x;
}
```

```
tutorial(9,8)=14
tutorial(1,2)=4
tutorial(16,2)=15
```

```
public float tutorial(int x, int y){
    if (x < 1 * y) return x + y;
    else if (y < 10 * Math.sqrt(x)) {
        return y + Math.abs(x - 2);
    }
    else return 3 * x;
}
```

```
tutorial(9,8)=15
tutorial(1,2)=3
tutorial(16,2)=16
```

```
public float tutorial(int x, int y){
    if (x < 2 * y) return x + y;
    else if (y < 10 * Math.sqrt(x)) {
        return y + Math.abs(x - 10);
    }
    else return 2 * x;
}
```

```
tutorial(9,8)=17
tutorial(1,2)=3
tutorial(16,2)=8
```

Final clause of the conditional is never used
Hence parameter C could be mutated without any effect on the output for these inputs!

Answer 5

```
public float tutorial(int x, int y){
    if (x < 1 * y) return x + y;
    else if (y < 10 * Math.sqrt(x)) {
        return y + Math.abs(x - 2);
    }
    else return 3 * x;
}
```

```
tutorial(17,17) = 32
```

```
public float tutorial(int x, int y){
    if (x < 2 * y) return x + y;
    else if (y < 10 * Math.sqrt(x)) {
        return y + Math.abs(x - 10);
    }
    else return 2 * x;
}
```

```
tutorial(17,17) = 34
```

Final clause of the conditional is never used
Hence parameter C could be mutated without any effect on the output for these inputs!

Crossover [1,2,3] and [2,10,2] to give [1,10,2]

```
public float tutorial(int x, int y){
    if (x < 1 * y) return x + y;
    else if (y < 10 * Math.sqrt(x)) {
        return y + Math.abs(x - 2);
    }
    else return 2 * x;
}
```

```
tutorial(17,17) = 24
```

Final clause of the conditional is never used
Hence parameter C could be mutated without any effect on the output for these inputs!
public float tutorial(int x, int y){
    if (x < 0 * y) return x + y;
    else if (y < 10 * Math.sqrt(x)) {
        return y + Math.abs(x - 3);
    }
    else return 5 * x;
}

Questions 7 and 8

7. Suppose you wanted to evolve programs which can produce spirographs by changing a unit square’s position and rotation over a hundred time steps, t, and rendering each square. Write down a suitable wrapper program.

8. Using the wrapper, fill in a program which might approximately produce each of the spirographs above
Answer 7

The wrapper program has to take in the time step, t, then set a rotation angle and a co-ordinate for the square and finally draw the square. The following would be suitable:

```c
int r = 0;
int x = 0;
int y = 0;

get_square(int t){
    // update r based on t
    // update x and y based on t
    drawSquare(x,y,r)
}
```

Answer 8

```c
int r = 0;
int x = 0;
int y = 0;

get_square(int t){
    x = 3 * t;
    y = 0 - (3 * t);
    drawSquare(x,y,r)
}
```

```c
int r = 0;
int x = 0;
int y = 0;

get_square(int t){
    r = 10*t;
    x = 2*t;
    y = t;
    drawSquare(x,y,r)
}
```