ITI 1121. Introduction to Computer Science II

Laboratory 6

Winter 2013

Objectives

- Creating a hierarchy of classes
- Further understanding of inheritance
- Further understanding of polymorphism
- Creating memory diagrams

Biological Game of Life

This laboratory brings together two problems. One of them is the Game of Life; invented by the Cambridge mathematician John Conway. The game consists of a two dimensional grid, where each cell is occupied or not. Based on simple rules, a cell can live, die or multiply. Since this laboratory is about inheritance, we are introducing a new concept to the game: let the content of a cell be an **Organism**, where an **Organism** can be either a **Plant** or an **Animal**. The animals are further divided into herbivores and carnivores. All the organisms have an **update** method that determines, based on its neighborhood, if this Organism will survive to the next generation. The particular survival rules depend on the particular Organism.

The class **Simulation** is the heart of this application. A run consists of fixed number of discrete generations. At the start of the simulation, a two dimensional grid is created and initialized with a population of organisms. At each generation, the simulation gathers, for each **Organism**, the list of its neighbors; a cell has a maximum of 8 neighbors. The method **update** of the Organism receives the list of neighbors and this information is used to determine if the **Organism** remains alive or dies. New organisms come to life at each generation, and the dead organisms are removed from the grid. The simulation ends when the maximum number of generations has been reached. You will be implementing the classes that determine behavior of the simulation; the class **Organism** and its descendants.

1 Organism

Implement an **abstract** class, called **Organism**, to represent the characteristics that are common to all the organisms. Namely,

1. An **Organism** is alive or not; all the organisms are alive at birth;
2. It has an instance method, `boolean isAlive()`, that returns **true** if this **Organism** is alive, and **false** otherwise;

3. It declares an **abstract** (instance) method, `void update( Organism[] neighbors )`, that will be implemented by the subclasses of Organisms.

2 Plant

Create a subclass of **Organism** to represent the characteristics of all plants. This will be a concrete class called **Plant**.

1. Give an implementation for the method `void update( Organism[] neighbors )`,
   - A **Plant** dies when surrounded by 5 or more neighboring organisms;
   - A **Plant** dies if it is surrounded by 2 or more Herbivores.

   If none of the above rules apply, a **Plant** can live forever.
2. Implement a method `public String toString()` to return the String "P" (quotes not included).

3 Animal

Create an **abstract** subclass of **Organism** to represent the characteristics of all animals, call this class **Animal**.

1. All animals have an age. At the birth of the **Animal**, its age is 0. At every generation (each call to the method update) the age will be incremented by 1;
2. Create an access method that returns the age of this **Animal**.

4 Herbivore

A **Herbivore** is an **Animal** that eats plants (i.e. is a subclass of **Animal**).

1. Implement the method `public void update( Organism[] neighbours )`, such that,
   - A **Herbivore** dies unless it is surrounded by at least one **Plant**;
   - A **Herbivore** cannot live more than 20 generations.
2. Implement a method `public String toString()` to return the String "H" (quotes not included).

5 Carnivore

A **Carnivore** is an **Animal** that eats other animals.

1. A **Carnivore** must eat regularly. If a **Carnivore** is not surrounded by at least one **Animal** for a given generation, this counts as one fasting generation;

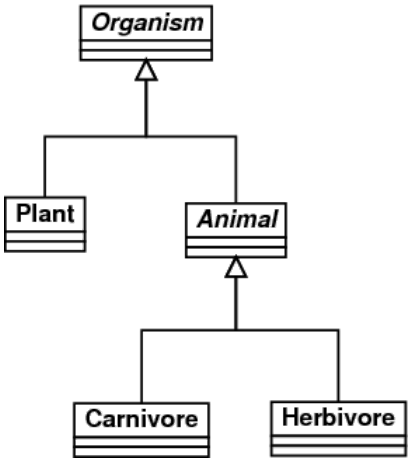
2. Implement the method `public void update(Organism[] neighbours)`, such that,
    - A **Carnivore** dies after four consecutive generations of fasting;
    - A **Carnivore** cannot live more than 15 generations.
3. Implement a method `public String toString()` to return the String "C" (quotes not included).

6 Simulation

As explained in the introduction, the Simulation is the hearth of this program. It creates the initial population of Organisms and orchestrates the simulation. Complete the implementation by creating the following two methods.

1. Implement the method `public String toString()` that displays the content of the grid. The format is as follows, the header consists of the label "Generation = " followed by the current number of generations. It is followed by a two dimensional grid of cells, where each cell is represented by the String "[X]", where X is a blank symbol (space) if the cell is not occupied or a symbol that depends of the particular Organism that occupies the cell. See below for an example;
2. Implement the method `public void tabulate()` that displays statistics about the current population. Specifically, it lists the total number of Organisms, Plants, Animals, Herbivores and Carnivores. See below for an example.

Class diagram



Files

- `Organism.java`
- `Plant.java`
- `Animal.java`
- `Herbivore.java`

- `Carnivore.java`
- Simulation.java

7 Quiz (1 mark)

- Draw memory diagrams for all variables and objects created during the execution of the main method below.

```
class Singleton {
    private int value;
    Singleton( int value ) {
        this.value = value;
    }
}

class Pair {
    private Object first;
    private Object second;
    Pair( Object first, Object second ) {
        this.first = first;
        this.second = second;
    }
}

public class Quiz {
    public static void main( String[] args ) {
        Singleton s;
        Pair p1, p2;

        s = new Singleton( 99 );
        p2 = new Pair( s, null );
        p1 = new Pair( s, p2 );
    }
}
```

Create a file called README.txt containing your name, student id, as well as the answer to the above quiz. Put all the files that were created for this assignment, including the README file, into a directory called **l5_123456**, where 123456 has been substituted by your student id. Create a **jar** file with the content of that directory (make sure that it has a top directory named **l5_123456**). Now submit the archive (**l5_123456.jar**) using Blackboard Learn:

- http://uottawa.blackboard.com/

- If your TA agrees with this, you can draw the memory diagrams for the quiz on a piece of paper (with your name and student id) that you will hand in to her (him). You still need to upload the files for the assignment on the Virtual Campus.

Example of an output

```
> java Simulation
Generation = 0
[P][ ][ ][P][P][ ][ ][P][ ][C]
[P][ ][ ][P][ ][P][ ][ ][ ][ ]
[P][ ][P][ ][ ][ ][P][ ][ ][ ]
[P][H][ ][P][P][C][H][H][ ][C]
[ ][H][P][ ][ ][ ][ ][ ][ ][P]
[ ][H][P][P][ ][H][ ][ ][P][P]
[ ][ ][ ][ ][ ][ ][ ][P][ ][ ]
[P][ ][H][ ][P][ ][H][H][H][ ]
[ ][ ][P][ ][ ][ ][ ][C][ ][P]
[H][ ][P][ ][ ][ ][ ][ ][P][ ]

Organisms = 41
Plants = 26
Animals = 15
Herbivores = 11
Carnivores = 4

Generation = 1
[P][ ][ ][P][P][ ][ ][P][ ][C]
[P][ ][ ][P][ ][P][ ][ ][ ][ ]
[P][ ][P][ ][ ][P][ ][ ][ ][ ]
[ ][H][P][P][P][C][H][H][ ][C]
[ ][H][ ][ ][P][ ][ ][ ][P][P]
[ ][H][ ][P][ ][ ][ ][P][P][P]
[ ][ ][ ][P][P][ ][ ][ ][ ][ ]
[P][ ][H][ ][P][ ][H][H][H][ ]
[ ][ ][P][P][ ][ ][ ][C][ ][P]
[ ][ ][P][P][ ][ ][ ][ ][P][ ]

Organisms = 43
Plants = 30
Animals = 13
Herbivores = 9
Carnivores = 4

Generation = 2
[P][ ][ ][P][P][ ][ ][P][ ][C]
[P][ ][ ][P][P][P][ ][ ][ ][ ]
[P][ ][P][ ][ ][P][ ][ ][ ][ ]
[ ][H][ ][P][P][C][H][H][ ][C]
[ ][H][P][ ][P][ ][ ][P][ ][P]
```

```
[ ][ ][P][P][ ][ ][ ][P][P][P]
[ ][ ][P][P][P][ ][ ][ ][P][P]
[P][ ][H][ ][P][ ][ ][ ][H][P]
[ ][ ][P][P][P][ ][ ][C][P][P]
[ ][ ][P][P][P][ ][ ][ ][P][P]

Organisms = 50
Plants = 40
Animals = 10
Herbivores = 6
Carnivores = 4
```

Last Modified: February 10, 2013