Computer Science CS136 (Fall 2021)
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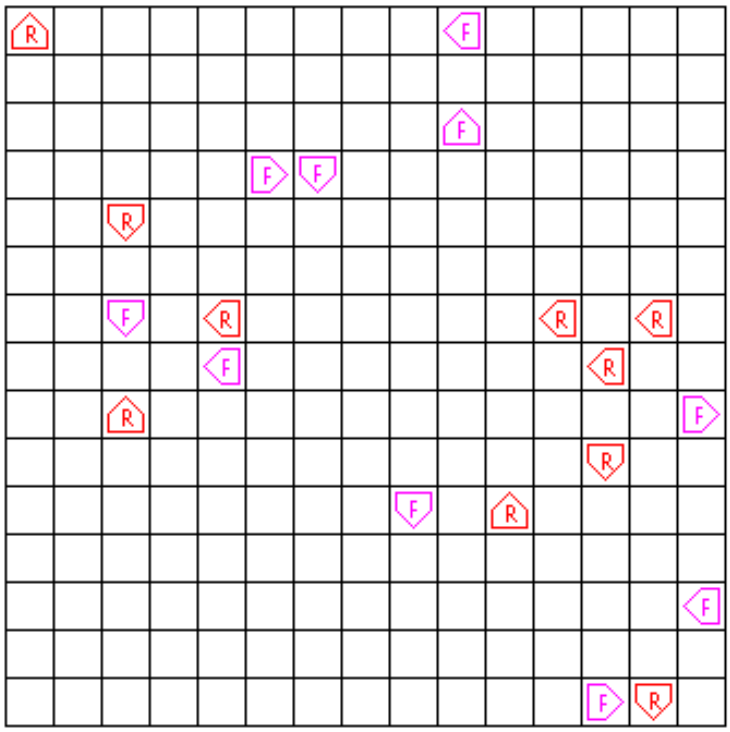
Laboratory 8
Darwin!—a lab by Steve Freund



Darwin's World Map

In this assignment, your job is to build a simulator for a game called Darwin (invented by Nick Parlante). The assignment has several general motivations:

1. We need more practice writing large, multi-class programs.
2. Darwin is a good example of modular decomposition and information hiding. The entire program is broken down into a series of classes that can be developed and tested independently, without revealing representational details.
3. Darwin poses a problem that is algorithmically interesting in its own right.

Most of this project is due in a week, just before Thanksgiving break.

The Darwin World

The Darwin program simulates a two-dimensional world divided up into small squares that is populated by a number of *creatures*. Each of the creatures lives in one of the squares, faces in one of the major compass directions (North, East, South, or West) and belongs to a particular species that determines how that creature behaves. One possible world is shown above.

That sample world is populated with twenty creatures, ten of a species called Flytrap and ten of a species called Rover. The species of the creature is identified by the first letter in its name. The creature

faces in the direction indicated by its pointy nose. The behavior of each creature—you can think of it as a small robot—is controlled by a *program* that is species specific. Thus, all of the Rovers behave in the same way. The behaviors of different species, however, are probably different.

As the simulation proceeds, every creature gets a turn. On its turn, a creature executes a short piece of its program that allows it to look forward and then take some *action*. The possible actions are (1) moving forward, (2) turning left or right, and (3) infecting the creature in front of it. (Infection transforms the victim into a member of the infecting species.) After it acts, the turn for that creature ends, and some other creature gets its turn. When every creature has had a turn, time moves forward one step and the process begins all over again with each creature taking another turn, and so on. The goal of the game is survive, as a species.

Species Programming

In order to know what to do on any particular turn, a creature executes some number of instructions in an internal program specific to its species. For example, the program for the Flytrap species is shown below:

Step	Instruction	Comment
1	`ifenemy 4`	If there is an enemy ahead, go to step 4
2	`left`	Turn left
3	`go 1`	Go back to step 1
4	`infect`	Infect the adjacent creature
5	`go 1`	Go back to step 1

The step numbers are not part of the actual program, but are included here to make it easier to understand the program. On its turn, a Flytrap first checks to see if it is facing an enemy creature in the adjacent square. If so, the program jumps ahead to step 4 and infects the hapless creature that happened to be there. If not, the program instead goes on to step 2, in which it simply turns left. In either case, the next instruction causes the program to loop from the beginning.

All creatures start their programs at step 1 and ordinarily continue with each new instruction in sequence, although this order can be changed by certain instructions in the program. Each creature is responsible for remembering the number of the next step to be executed. The valid Darwin instructions are:

hop The creature moves forward as long as the square it is facing is empty. If moving forward would put the creature outside the boundaries of the world or would cause it to land on top of another creature, the hop instruction does nothing.

left The creature turns left 90 degrees to face in a new direction.

right The creature turns right 90 degrees.

infect n If the square immediately in front of this creature is occupied by a creature of a different species (an 'enemy') that creature is infected to become the same as the infecting species. When a creature is infected, it keeps its position and orientation, but changes its internal species indicator and begins executing the same program as the infecting creature, starting at step n of the program. *The number n is optional. If it is missing, the infected creature should start at step 1.*

ifempty n If the square in front of the creature is unoccupied, the program continues from step n. If that square is occupied or outside the world boundary, continue with the instruction that follows.

ifwall n If the creature is facing and is at a world boundary (which we imagine as consisting of a huge wall) jump to step n; otherwise, continue with the next instruction.

ifsame n If the square the creature is facing is occupied by a creature of the same species, jump to step n; otherwise, continue with the next instruction.

ifenemy n If the square the creature is facing is occupied by a creature of another species, jump to step n; otherwise, go on with the next instruction.

ifrandom n In order to make it possible to write some creatures capable of exercising what might be called the rudiments of 'free will,' this instruction jumps to step n half the time and continues with the next instruction the other half of the time.

go n This instruction always jumps to step n, independent of any condition.

A creature may execute any number of `if` or `go` instructions without relinquishing its turn. The turn ends only when the program executes one of the "action" instructions `hop`, `left`, `right`, or `infect`. On subsequent turns, the program starts up where it left off.

The program for each species is stored in a file in the subfolder named `Creatures` in the assignment folder. Each file in that folder consists of the species name and color, followed by the steps in the species program, in order. The program ends with a line containing only a period (`.`). Any comments appear after the program. For example, the program file for the Flytrap creature could look like this:

```
Flytrap
magenta
ifenemy 4
left        go 1
infect      go 1
.
The flytrap sits in one place and spins.
It infects anything which comes in front.
Flytraps do well when they clump.
```

There are several pre-supplied creature files:

Food This creature spins in a square but never infects anything. Its only purpose is to serve as food for other creatures. As Nick Parlante explains, "the life of the Food creature is so boring that its only hope in life is to be eaten by something else so that it gets reincarnated as something more interesting."

Hop This creature just keeps hopping forward until it reaches a wall. Not very interesting, but it is useful to see if your program is working.

Flytrap This creature spins in one square, infecting any enemy creature it sees.

Rover This creature walks in straight lines until it is blocked, infecting any enemy creature it sees. If it can't move forward, it turns.

You can also create your own creatures by creating a description file in the format described above.

Your Assignment

Write the Darwin simulator. The program is large enough that it is broken down into a number of separate classes that work together to solve the complete problem. You are responsible for implementing the following classes:

Darwin This class contains the main program, which is responsible for setting up the world, populating it with creatures, and running the main loop of the simulation that gives each creature a turn. The details of these operations are generally handled by the other modules. New creatures should be created in random empty locations, pointing in random directions.

Species This class represents a species, and provides operations for reading in a species description from a file and for working with the programs that each creature executes.

Creature Objects of this class represent individual creatures, along with operations for creating new creatures and for taking a turn.

World This class contains an abstraction for a two-dimensional world, into which you can place the creatures.

Skeletons of these classes are provided in the starter folder. You should not need to add any additional public methods to these classes (although you may if you think it improves the design). You will, however, probably want to add additional protected methods as you implement the classes. In addition, we provide you with three helper classes that you should use without modification:

Instruction This simple class represents one instruction out of the instruction set of the `Species`.

Position This class represents (x, y) points in the world and constants for compass directions. This is similar to what we used in the our maze-related classes.

WorldMap This class handles all of the graphics for the simulation.

This Week's Tasks

Here is a suggested course of action to implement Darwin:

1. *On the CS machine in front of you*, make sure you have a `cs136` directory and clone your `lab8` repository as usual:

   ```
   cd ~/cs136
   git clone https://evolene.cs.williams.edu/cs136-labs/22xyz3/lab8.git
   ```

   replacing 22xyz3 with your CS username. This will create the directory `~/cs136/lab8`.

2. You can use the command `darwin` on the local computer[1] to run Steve's sample solution. This will give you a chance to see how the program is supposed to behave. Run it with a command line like

[1] Because this program opens a graphics window, it is difficult to run through ssh. During lab, we suggest you clone the repository on the Mac Lab computer you're sitting in front of. In the `jar` subdirectory, we've included a copy of `bailey.jar` if you wish to add the `structure5` package to your `CLASSPATH` with the unix command:

```
export CLASSPATH=.:$HOME/cs136/lab8/jar/bailey.jar:$CLASSPATH
```

This command can be made permanent by adding it to the file `.zprofile` in your home directory.

```
./darwin Hop.txt Rover.txt
```

while inside the lab folder.

3. Write the `World` class. This should be straight-forward if you use a `Matrix` object or a 2-dimensional array to represent the world. **Test this class thoroughly before proceeding. Write a main method in the World class and verify that all of the methods work.**

4. Write the `Species` class. The first step will be parsing the program file and storing it in the `Species`. Note that the first instruction of a program is at address 1, not 0. **Test this class thoroughly before proceeding. Write a main method in the `Species` class and verify that all of the methods work.**

5. Fill in the basic details of `Creature` class. Implement only enough to create creatures and have them display themselves on the world map. Implement `takeOneTurn` for the simple instructions (`left`, `right`, `go`, and `hop`). **Test the basic `Creature` thoroughly before proceeding. Write a `main` method in that class and verify that all of the methods work.**

6. Begin to implement the simulator in the `Darwin` class. Start by reading a single species and creating one creature of that species. Write a loop that lets the single creature take 10 or 20 turns.

7. Go back to `Creature` and implement more of the `takeOneTurn` method. Test as you go—implement an instruction or two, and verify that a `Creature` will behave correctly, using your partially written Darwin class.

8. Finish up the `Darwin` class. Populate the board with creatures of different species and make your main simulation loop iterate over the creatures giving each a turn. The class should create creatures for the species given as command line arguments to the program when you run it. See `Darwin.java` for more details. Run the simulation for several hundred iterations or so. You can always stop the program by pressing control-C in the terminal window or closing the `Darwin` window.

9. Finally, finish testing the implementation by making sure that the creatures interact with each other correctly. Test `ifenemy`, `infect`, etc.

Deliverables

1. Turn in the following five files before Thanksgiving:
   (a) Final version of `World.java`
   (b) Final version of `Species.java`
   (c) `Creature.java`
   (d) `Darwin.java`
   (e) A `Species` of your own design, in the `Creatures` directory, a file called `Creature.txt` (internally, of course, it can be named whatever you wish). It can be as simple or as complex as you like. When we return from Thanksgiving, we will pit your creatures against each other to watch them battle for survival. Fabulous door prizes will be awarded. We will run all simulations on a 15x15 grid populated with 10 creatures from each of 4 species.

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