

**ASSIGNMENT OVERVIEW**

In this assignment you'll be creating a program called `game_of_life.py`, which will allow the user to run a text-based or graphics-based simulation of John Conway's game of *Life* on the computer.

This assignment is worth 75 points and is due on the *crashwhite.polytechnic.org* server at 23:59:59 on the date given in class.

**BACKGROUND**

John Conway's game of *Life* is a type of *cellular automata* that demonstrates how simple rules can lead to complex patterns or behaviors.

In *Life*, the “world” is simulated on a large, two-dimensional grid, with each cell in the grid either empty or occupied by an “organism.” In the course of a turn, the contents of each cell are determined by looking at the eight cells surrounding it. In the basic game, an organism in one cell will be born, or live, or die, according to the following rules:

1. A live cell with  $< 2$  neighbors will die (due to under population).
2. A live cell 2-3 neighbors lives on to the next generation.
3. A live cell with  $> 3$  neighbors dies (due to overpopulation).
4. An empty cell with 3 neighbors becomes a live cell (from reproduction).

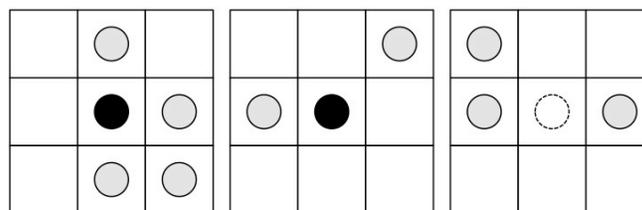


Figure 1.

Figure 2.

Figure 3.

In Figure 1, the cell whose neighbors are being counted is at the center and colored black. (In the program's output, however, all “live” cells will have the same color, shape, or designation—see the *Sample Interactions* at the end of this document.) The neighbors in the eight surrounding squares are colored gray, and in this first case, the black colored cell will “die” during this generation in this area of the board—it has four or more occupied cells around him.

In Figure 2 the live cell at the center will survive into the next generation because it has 2-3 neighbors around it.

In Figure 3, the empty cell in the center will be the site of a live cell in the next generation (indicated here by an uncolored dashed circle), thanks to the existence of the three neighbors surrounding it.

See [https://en.wikipedia.org/wiki/Conway's\\_Game\\_of\\_Life](https://en.wikipedia.org/wiki/Conway's_Game_of_Life) for further information on this game.

```

..00.000.0.....000...
...00..0.....
.....00.....
.....0.....00.....
00...0.....000.....
00..00.....0..000...
.....000.00.
.....0.....0..0..

```

The *model* for this game might take a number of forms depending on how you choose to code it: a **boolean** “list of lists” with live cells **True** and empty cells **False**; a **str** “list of lists” with “.” and “0”; an **int** “list of lists” with 0s and 1s. This Model of the game is internal, and isn’t something that the user will have any direct interaction with.

The *view* for the game that the user sees is also up to you: a text-based version might simply display the strings in your array, or display characters based on the true-false values in a boolean array; a graphics-version will take the cells and display them as pixels, or perhaps as squares in a grid.

Running a simulation consists of establishing a “board” for the grid of cells, populating the cells with an initial “seed” generation, and then watching the population on the board evolve over time as successive generations are produced according to the population rules above.

### **PROGRAM SPECIFICATION**

Create a Python program, with associated functions, that:

- a. includes appropriate documentation
- b. creates a 2-dimensional list of lists on which the simulation will run
- c. populates the array randomly (or possibly by user selection of cells)
- d. displays the initial state of the array on screen
- e. uses the basic rules of Conway’s *Life* to calculate a new generation
- f. displays the new state of the array on screen
- g. repeats this process until the user breaks out of the program

### **DELIVERABLES**

**game\_of\_life.py**

To submit your assignment for grading, copy your file to your directory in `/home/studentID/forInstructor/` at [crashwhite.polytechnic.org](http://crashwhite.polytechnic.org) before the deadline.

### **ASSIGNMENT NOTES**

- This program will probably consist of a main program and 2-3 functions. You’ll definitely have a `main()` function, and possibly a `create_empty_world()` function, a `fill_world()` function, a `print_world()` function, a `count_neighbors()` function, a `get_next_generation()` function...
- Because this simulation is observed via a display, you’ll need to decide whether you want to run a text-based simulation or a graphics-based simulation. The text-based simulation is easier to program but doesn’t look as good, while the graphics-based version allows for greater detail (the

cells are smaller), at the cost of increased programming complexity.

- If using the text-based display, you'll want to clear the screen between the display of successive generations. In Apple's macOS you can use this code for that purpose:

```
import os
os.system("clear")
```

- To create the initial seed generation of cells, have the program randomly populate the board. As a follow-up option you can either have the user specify cells to be populated in the first generation.
- You'll actually need *two* 2-d arrays when running this simulation: one for the current population state, and one that you'll create for the next population when the rules of *Life* are applied. Once the rules have been applied to completely create the entire next population, the contents of that array will be transferred into the original array, and the process repeats from there.
- When counting neighbors, the eight squares surrounding a given cell should be evaluated using a nested **for** loop. If a given cell is populated, a **sum** counter is incremented, and the final result of that **sum** counter is used to determine the fate of that cell in the next generation. In the example below, `board[1][4]` has eight cells around it that should be evaluated. Note that gray cells in the example are not part of the board, and should *not* be evaluated. Attempts to identify a cell that is outside the bounds of the board—when looking at `board[0][0]`, for example—will cause an error.

columns

	0,0	0,1	0,2	0,3	0,4	0,5
rows	1,0	1,1	1,2	1,3	1,4	1,5
	2,0	2,1	2,2	2,3	2,4	2,5

- You will probably find that the simulation runs faster than your computer display can refresh, producing some odd flickering effects. Most programs will require a brief delay between screen refreshes. You can use this code to introduce a pause for some number of seconds:

```
import time
time.sleep(0.1)    # delays program for 0.1 seconds
```

## GETTING STARTED

1. With paper and pencil, and perhaps in collaboration with a partner, run a small, simple Life simulation on paper to make sure you understand the rules.
2. Identify what the main components are that you'll need to include in your program.

3. Sketch out the basic flow of your program using a flowchart, and write some pseudocode that you can use to begin implementing those main components.
4. Start a new `game_of_life.py` program that you will submit for this assignment.
5. Write a `fill_world()` function that you will use to construct and manipulate the initial board. Also, write a `print_world()` function that will display the world. Test these classes before moving on.
6. Write a `get_next_generation()` function that will calculate what the next generation of cells will look like. This function may use an additional function called `count_neighbors()` that you can write.
7. Much of your program will consist of working through the contents of the board. It is common to use nested loops for this process:

```
for row in range(rows):
    for col in range(cols)
        # do stuff with board[row][col]
```

8. *Test each bit of code as you go*, making sure that one piece works before you proceed on to the next section. You'll repeatedly run through this edit-compile-test, edit-compile-test process to progressively find bugs and fix them *while* you're writing your program, not afterwards.
9. Save your program from time to time, and once a day or so, save a backup copy of it on another device or machine: a flash drive, your home folder on the *crashwhite.polytechnic.org* server, etc.
10. When your program is completed (but before the deadline), copy a final archived package to the server as indicated above.

### **QUESTIONS FOR YOU TO CONSIDER (NOT HAND IN)**

1. What is a *cellular automata*?
2. Names have been given to many of the forms that arise in a typical game of Life. A *block*, *beehive*, or *loaf*, is not uncommon, and you're sure to see a *blinker*. If you're lucky, you might see a *glider* skittering across the screen.
3. Conway's original game of Life is a 2-dimensional cellular automata, with a set of rules that govern the calculation of future states. What would a 1-dimensional cellular automata look like? What rules would allow one to calculate future states? See [https://en.wikipedia.org/wiki/Elementary\\_cellular\\_automaton](https://en.wikipedia.org/wiki/Elementary_cellular_automaton) for an interesting discussion.
4. Would you get a *glider* tattoo? Would you buy a 1-d cellular automata scarf?

