

**Lab 1: Game of Life**

**In-Lab:** Wednesday, January 13, 2010

**Due:** Tuesday, January 19, 2010

**Overview**

The Game of Life, invented by John Conway in 1970, is an example of a zero-player “game” known as a cellular automaton. The game consists of a two-dimensional world extending infinitely in all directions, divided into “cells.” Each cell is either “dead” or “alive” at a given “generation.” The game consists of a set of rules that describe how the cells evolve from generation to generation. These rules calculate the state of a cell in the next generation as a function of the states of its neighboring cells in the *current* generation. In a 2-D world, a cell’s neighbors are those 8 cells vertically, horizontally, or diagonally adjacent to that cell. Conway’s set of rules are summarized as:

1. A live cell with fewer than two live neighbors dies.
2. A live cell with more than three live neighbors also dies.
3. A live cell with exactly two or three live neighbors lives.
4. A dead cell with exactly three live neighbors becomes alive.

In this lab, we will be implementing Conway’s Game of Life, with the minor restriction that our 2-D world is finite. The neighbors of a cell on the edge of the world that would be beyond the edge are assumed dead. You can read more about Conway’s Game of Life on Wikipedia at [http://en.wikipedia.org/wiki/Conway's\\_Game\\_of\\_Life](http://en.wikipedia.org/wiki/Conway's_Game_of_Life).

Example (the so-called “glider”):

*		*
*   *	→	* *
* *		* *

Legend: \* = alive, \_ = dead

**Part A: Implementing Evolution (In-Lab)**

In this part, we will focus on implementing the rules needed to evolve the world from one generation to the next. To assist you, we provide several functions you should use to access and modify the current and next state of the world. These functions are described in the header file `lifegame.h` and implemented in the file `lifegame.c`. Also, we have provided a skeleton describing what you need to do for this part in `lab1a.c`.

Before getting started, you should copy all these files from the locker (`/mit/6.087/Lab1/`) into your working directory. When compiling, you need to compile `lab1a.c` and `lifegame.c` together to generate a single executable file (let's call it `lab1a.o`) with all the code in it (otherwise, you'll get "undefined reference" errors). Here's an example command line for compiling this code:

```
athena%1 gcc -g -O0 -Wall lab1a.c lifegame.c -o lab1a.o
athena%
```

Start by examining the contents of `lifegame.h` and `lab1a.c`. You need to fill in a few lines in `main()` and complete the functions `next_generation()`, `get_next_state(x,y)`, and `num_neighbors(x,y)`. There is no need to modify the files `lifegame.h` or `lifegame.c` in this part.

- (a) How will you initialize the world for the Game of Life? Write the appropriate code in the `main()` function.
- (b) How will you output the final state of the world once all the evolutions are done? Write the appropriate function call in `main()`.
- (c) The `main()` function calls `next_generation()` for each generation to handle the evolution process. Your code should set each cell's state in the next generation according to the rules specified in the Overview of this handout. Once the states of all the cells have been set for the next generation, calling `finalize_evolution()` will set the current world state to the next generation and reset the next generation state. Your code should make use of the `get_next_state(x,y)` function to compute the next state of each cell.
- (d) Write the code for `get_next_state(x,y)`, so the function returns the next state (ALIVE or DEAD) of the cell at the specified coordinates using the number of live neighbors (returned by the `num_neighbors(x,y)` function) and the Game of Life rules.
- (e) Fill in the function `num_neighbors(x,y)`, so it returns the number of live neighbors (cells vertically, horizontally, or diagonally adjacent) for the specified cell. Since our world is finite, adjacent cells which are beyond the edge of the world are presumed DEAD.

Now that you're done, compile and run the program. Feel free to change the definition of `NUM_GENERATIONS`, but when you're ready to be checked off, make sure `NUM_GENERATIONS = 50` and show your program's output to the Lab Assistant.

Check off: \_\_\_\_\_

## Part B: The World in a File

In the first part of this lab, the initial state of the world was hard-coded into `lifegame.c` and the final state of the world was output to the console. In this part, we will modify the code so that the initial state of the world can be read from a file, and the final state is output to a file.

First, let's examine `lifegame.c`. Notice the functions you need to implement: `initialize_world_from_file(filename)` and `save_world_to_file(filename)`.

<sup>1</sup> Athena is MIT's UNIX-based computing environment. OCW does not provide access to it.

- (a) The first of these, `initialize_world_from_file(filename)`, reads the file specified by `filename` and initializes the world from the pattern specified in the file. Basically, the file is a matrix of characters, '\*' to specify a live cell, and ' ' (space) to specify a dead cell. The  $i$ th character of the  $j$ th line (zero-indexed) represents the initial state of the cell located at  $(i,j)$ . If the line doesn't contain enough characters or the file doesn't contain enough lines, the unspecified cells are presumed dead. Fill in the function to read the file and initialize the world. Don't forget to reset all the next generation states to DEAD. Use appropriate error handling.
- (b) The other function, `save_world_to_file(filename)`, saves the final state of the world to the file `filename` in the same format as used in the initialization function: the  $i$ th character of the  $j$ th line (zero-indexed) represents the state of the cell located at  $(i,j)$  in the world.
- (c) Fill in the contents of `lab1b.c` using the code from Part A (`lab1a.c`) and modifying to call these functions. The name of the file to load will be specified in the first command line argument passed to the executable. If no file is specified, you should default to initializing the world to the hard-coded default "glider" pattern. Save the final output to the file "world.txt."

To help you test your code, we've provided a couple test files: `glider.txt` (should match your output from Part A) and `sship.txt` (output in `sshipout.txt`).

To finish, write a brief (1 page max.) lab report describing your experience completing this lab, what challenges you faced and how you addressed them, and what you learned from this lab. Turn in a zip file containing all your code (`lab1a.c`, `lab1b.c`, `lifegame.h`, and `lifegame.c`), and your lab report, using the online submission system on Stellar.

Congratulations, you're done!

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