METHODOLOGIES FOR DISCRETE EVENT MODELING AND SIMULATION

SYSC 5104

Assignment #2

A Cellular Model Simulation of Fish Migration

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Part I: Introduction

Problem Description

Normally, lots of dams are built over rivers which are used for irrigation or hydropower, but also become barrier for fish migration. In order to protect the ecosystem balance, some measures need be taken to facilitate the migration of fish. However, the budget which is devoted to improve the facility on river is always limited. We should be careful to use limited resource. So we need to build a model to simulate fish migration under different conditions so that different strategies imposed on river could be evaluated.

In this assignment, I plan to build one cellular model to simulate fish migration.

In my model, upstream migration will be considered only. A river is supposed to be made up of fragments separated by dams. Each fragment is represented by one cell with a state ($s \in E = \{0, 1, \ldots, n\}$, where n is the total number of simulated fish). The state of a cell is interpreted as the number of fish present in this cell. For each cell, a number $pi \in [0, 1]$ is assigned, representing the probability that one fish successfully migrates into this cell in one try.

A river may have several branches which is also represented by cells. Fish migrates from the river entry to the source of mainstream or branches. Eventually, only a part of fish can arrive at the source successfully. We can obtain a total number of arriving fish after simulation which is used to assess the effect of selected strategy.

Part II: Formal Specification

River Model

In this model, a river is represented by coupled cells in a no wrapped 5 x 10 grid. Each cell is initialized by default value(-1 or 0). -1 represents the border of river while 0 represents fragments of river.I build a cellular river model as follow:

-1	0	-1	-1	-1	-1	-1	-1	-1	-1
-1	0	-1	-1	-1	-1	-1	-1	-1	-1
0	0	0	0	0	0	0	0	0	0
-1	-1	0	-1	-1	-1	-1	-1	-1	-1
-1	-1	0	-1	-1	-1	-1	-1	-1	-1

Just as shown above, the river has 2 branches. The most left 0 cell is river entry while the most right 0 cell is the source of mainstream. The top 0 cell is the source of up branch while the bottom 0 cell is the source of down branch.

Fish entries the river at the most left 0 cell and eventually arrives at the most right 0 cell, or top 0 cell or bottom 0 cell.

Neighbor Cell

For each cell, its' neighbors are defined as follow:

```
neighbors : migration(-1,-1) migration(-1,0) migration(-1,1)
neighbors : migration(0,-1) migration(0,0) migration(0,1)
neighbors : migration(1,-1) migration(1,0) migration(1,1)
```

(-1,-1)	(-1,0)	(-1,1)
(0,-1)	(0,0)	(0,1)
(1,-1)	(1,0)	(1,1)

Migration Model

At the beginning, a number of fish, says 500, entries the river which means the most left 0 cell will be set to 500. Every interval, a small part of fish, says 2 fishes, will set out to begin its migration which means the value of most left 0 cell will be reduced gradually.

And only a portion of fishes can migrate into the next cell successfully while the other portion of fishes die or disappear. A number pi ∈ [0, 1] is assigned to every 0 cell which represents the probability that one fish successfully migrates into the next cell.

The next cell's value will be set to the number of survival fishes from last cell after one interval. During the next interval, the fishes in current cell will try to migrate to the next cell and survival fished from last cell will arrive again.

Normally, in this model, fish tries to migrate to their left cell every interval. However, if there is a branch, fish will decide to migrate to the next cell of mainstream or the branch. In this model, we suppose the probabilities of those 2 cases are all 50%, which means, at the conjunct cell, fish migrate to the next cell of mainstream in the probability of 50%, or to the branch in the probability of 50%.

The migration procedure will be iterated until all fishes at the river entry complete their migration. At that time, all survival fish is distributed at the source of mainstream or branches. Each source cell contains a number of fish which complete migration successfully. The data can be used to analyze and evaluate effect of different strategies

Part III: Simulation and Results

As described above, Pi is assigned to each cell of river which represents the probability that a fish can migrate to this cell successfully. 2 sets of Pi are used during simulation. One is a constant Pi = 0.57. The other one is a function of the distance between current cell and the river entry cell, which can be expressed as follow:
Pi = (9 - cellPos(1)) / 9) in cell of mainstream,
Pi = ((9 - cellPos(1) + 2 - cellPos(0)) / 9) in cell of up branch stream
Pi = ((9 - cellPos(1) + cellPos(0) - 2) / 9) in cell of down branch stream

Consequently, 2 simulations are performed according to different Pi set.

Migration1

In this simulation, Pi is a constant 0.57.

500 fishes is placed into the river entry to start the simulation.

The simulation result is demonstrated as follow:

```
Line : 110 - Time: 00:00:00:000
          0       1       2       3       4       5       6       7       8       9
   +--------------------------------------------------------------------------------+
  0|  -1.00           -1.00   -1.00   -1.00   -1.00   -1.00   -1.00   -1.00   -1.00|
  1|  -1.00           -1.00   -1.00   -1.00   -1.00   -1.00   -1.00   -1.00   -1.00|
  2|                                                                         500.00|
  3|  -1.00   -1.00           -1.00   -1.00   -1.00   -1.00   -1.00   -1.00   -1.00|
  4|  -1.00   -1.00           -1.00   -1.00   -1.00   -1.00   -1.00   -1.00   -1.00|
   +--------------------------------------------------------------------------------+
```

```
Line : 14968 - Time: 00:00:25:900
            0        1        2        3        4        5        6        7        8        9
    +-------------------------------------------------------------------------------------------+
   0|   -1.00     0.45    -1.00    -1.00    -1.00    -1.00    -1.00    -1.00    -1.00    -1.00|
   1|   -1.00             -1.00    -1.00    -1.00    -1.00    -1.00    -1.00    -1.00    -1.00|
   2|    0.79                                                                                  |
   3|   -1.00    -1.00             -1.00    -1.00    -1.00    -1.00    -1.00    -1.00    -1.00|
   4|   -1.00    -1.00     1.59    -1.00    -1.00    -1.00    -1.00    -1.00    -1.00    -1.00|
    +-------------------------------------------------------------------------------------------+
```

As shown, eventually, 0.79 fish arrive at the source of mainstream successfully while 0.45 fish at the source of up branch and 1.59 fish at the source of down branch.

More details of simulation procedure can refer to packaged files and video file.

Migration2

In this simulation, Pi is a is a function of the distance between current cell and the river entry cell.

500 fishes is placed into the river entry to start the simulation.

The simulation result is demonstrated as follow:

```
Line : 110 - Time: 00:00:00:000
            0        1        2        3        4        5        6        7        8        9
    +-------------------------------------------------------------------------------------------+
   0|  -1.000            -1.000   -1.000   -1.000   -1.000   -1.000   -1.000   -1.000   -1.000|
   1|  -1.000            -1.000   -1.000   -1.000   -1.000   -1.000   -1.000   -1.000   -1.000|
   2|                                                                                  500.000|
   3|  -1.000   -1.000            -1.000   -1.000   -1.000   -1.000   -1.000   -1.000   -1.000|
   4|  -1.000   -1.000            -1.000   -1.000   -1.000   -1.000   -1.000   -1.000   -1.000|
    +-------------------------------------------------------------------------------------------+
Line : 14968 - Time: 00:00:25:900
            0        1        2        3        4        5        6        7        8        9
    +-------------------------------------------------------------------------------------------+
   0|  -1.000    0.130   -1.000   -1.000   -1.000   -1.000   -1.000   -1.000   -1.000   -1.000|
   1|  -1.000            -1.000   -1.000   -1.000   -1.000   -1.000   -1.000   -1.000   -1.000|
   2|   0.117                                                                                 |
   3|  -1.000   -1.000            -1.000   -1.000   -1.000   -1.000   -1.000   -1.000   -1.000|
   4|  -1.000   -1.000    0.234   -1.000   -1.000   -1.000   -1.000   -1.000   -1.000   -1.000|
    +-------------------------------------------------------------------------------------------+
```

As shown, eventually, 0.117 fish arrive at the source of mainstream successfully while 0.130 fish at the source of up branch and 0.234 fish at the source of down branch.

More details of simulation procedure can refer to packaged files and video file.