Excercise 1.
Implementing a first Application in RePast: A Rabbits Grass Simulation.

Group №66: Amaury Combes, Tho Nikles

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1 Implementation

1.1 Assumptions

Numerous assumptions were required, since the description of the world model let us a lot of freedom. Especially, in our world model, the grass can stack on a cell, if it spreads on a place where there already is grass. Grass cannot spread under a rabbit, this prevents having the grid full of rabbits forever (if they have a lot of energy and a big growth rate for the grass). The grass energy is set before launching the program and is fixed. Also, we assumed that the grid has a square shape (NxN).
The graph shows the evolution of rabbits (in red) and of grass (in blue). It is important to note that the grass population is the number of cell containing grass, rather than total number of grass (sum of the amounts of grass) of all cells.
The following sequence of events happens at each tick, in this order:

1. Each agent perform one step
2. We remove the dead agents
3. We add the new agents
4. We finally spread the grass in the world

1.2 Implementation Remarks

Here are some implementation details, this part completes section 1.1 and give precision about the code. If a grass grow on a cell, it will add 1 to the total count of grass at that cell. When a rabbit goes on a cell, it eats the total number of grass.
An agent always try to move to all directions around him, it randomly picks a direction between all those that are "legal" (it doesn't make it enter in collision with another rabbits). If there is no such direction, it stays on the cell it is when it tries to move, and will try the next tick.
There are two variables, min and max lifespan, that defines the minimum and the maximum of energy with which an agent will be born. The exact amount of energy is randomly chosen between these two boundaries.
The reproduction takes half of the energy of a rabbit, this prevents the agents to give too much birth. The displays are not probeable, because we didn't find that it adds something for the program.

2 Results

Here are the default values used for the experiences, for every single of them, the modified variables are given in the **setting** section.

- Grid size = 20
- Rabbits number = 10
- Birth threshold = 150
- Grass growth rate = 100
- Minimum lifespan = 90
- Maximum lifespan = 110

Note that we only vary the size of the grid. Because we found that these were the most interesting observations and already contains a good sense of how the different variables impacts the environment. Here are a few additional notes. The initial number of rabbits changes the beginning of the simulation, but they always tend to reach an equilibrium, which is unmodified by that variable. A too small grass growth rate will cause the extinction of the rabbit population, while a big one will allow the population to become huge and even completely cover the space (for a while). A huge birth threshold cause the extinction of the rabbit population while a really small allows the population to become huge (in extreme case, there is no need to have any grass growing to have continuous population of rabbits). For example, with the default values, by changing grass growth rate to 0 and birth threshold to 10, there is a continuous 400 rabbits population because they are born with enough energy to reproduce and keep this ability long enough to replace a rabbit that will die, and so on.

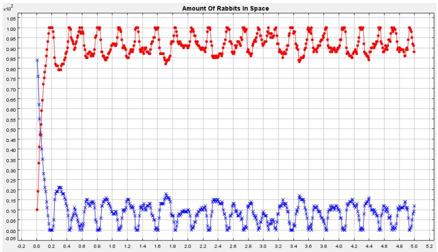
2.1 Experiment 1

2.1.1 Setting

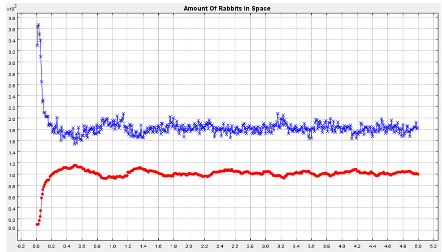
For this first experience, we look at how changing the grid size affects the population of rabbits and the one of grass. The grid size will be respectively 10x10, 20x20 and 50x50

2.1.2 Observations

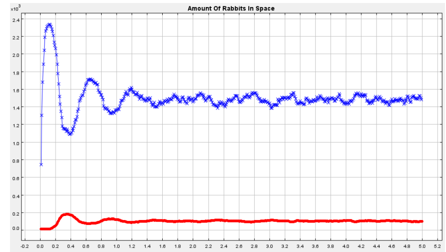
For the 10x10 grid size, the great number of grass that grows at each tick allows the rabbits to always find food around them and keep their energy high. This allows so much reproduction that there often is a rabbit on each cell of the grid (100 rabbits, as one can see on the first graph). Since we prevent grass growth under a rabbit, they simply lose their energy until some dies, which allows grass to grow again, and rabbits to find enough energy to reproduce. We're in a cycle and it doesn't change anymore.
For the 20x20 grid size, we reach an equilibrium of approximately 180 ± 30 grasses and approximately 100 ± 20 rabbits in our simulation. One can already note that incrementing the grid size allowed grass to develop more than rabbits.
Finally, for 50x50 grid size, there is also an equilibrium and the population of grass becomes much greater than the population of rabbits. As before, the differences in the population is much greater for grass than for rabbits (approximately 1450 ± 150 against 100 ± 10 respectively for the grass and the rabbits. This happens because there is grass growing at each tick but a rabbit needs to gain a lot of energy to be able to reproduce.
Here are the different results graph, side by side, where the blue line is the grass line and the red one the rabbits:



10x10 grid



20x20 grid



50x50 grid

2.2 Experiment 2

2.2.1 Setting

For the second experiment, we find out what happens if we push the observations of the first one to its limit. We made the grid bigger and bigger until reaching a size for which something new happens. It does for a grid of 110x110, so it is the only variable that changes for this experiment.

2.2.2 Observations

The rabbits are not able to eat enough grass and die without reproducing. Hence there is only grass that can grow at its ease in the world until it covers every cell. It never disappears since there is no rabbit to eat it. It stops growing when it reaches $110 \cdot 110 = 12100$.
This also happens if we set a too small grass growth rate, because there is not enough grass for the rabbits to survive.

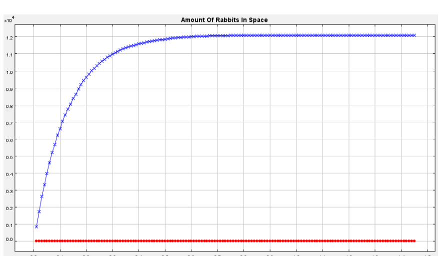
2.3 Experiment 3

2.3.1 Setting

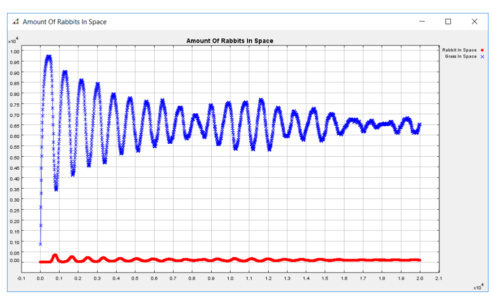
For this experiment, we set the grid size to 100x100.

2.3.2 Observations

This setting allows the population to reach an equilibrium but it is interesting to note that the population of grass and rabbits have a direct impact on each other. When the grass population gets bigger, it becomes easier for the rabbits to find food and gain energy. This leads to rabbits surviving through times and gaining enough energy to reproduce, making the population bigger. But since there is more and more rabbits, there is less and less grass. This leads to a lack of energy and rabbits begin to die. Since there is less rabbits, grass can once again grow on more and more places without being eaten. And we finished on cycle of one of these endless oscillations.



exp 2 110x110 grid



exp 3 100x100 grid