Exercise 1.
Implementing the first Application in RePast: A Rabbits Grass Simulation.

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1 Implementation

1.1 Assumptions

Each cell in the world can be occupied with at most 16 grass units. If a rabbit goes onto a cell with grass, it eats the whole amount of grass on the given cell and increases its energy level by that amount. If a rabbit tries to go onto a cell already occupied by another rabbit, it tries to move randomly again. During the simulation, grass grows randomly depending on the grass growth rate.

We added new simulation parameters: AgentMinEnergy, AgentMaxEnergy, BirthTrashold, BirhGivingLoss, BabyLifeSpan, BirthFrequency.

The initial rabbit's energy is a random value between AgentMinEnergy and AgentMaxEnergy. If a rabbit has enough energy to reproduce, i.e. it has energy greater than BirthTrashold, it gives birth to a new baby rabbit that is placed randomly on the grid. The parent rabbit might lose some energy during birth-giving specified by BirthGivingLoss. This parameter is a real value in $[0, 1]$ and represents what percentage of the energy the rabbit loses during the birth-giving. The newborn baby's energy has a value of BabyLifeSpan (bounded by AgentMinEnergy and AgentMaxEnergy). Additionally, after giving birth a rabbit has to wait for BirthFrequency steps to be able to reproduce again.

For all experiments we used grid size 20.

1.2 Implementation Remarks

When a new rabbit is supposed to be added to space (initial rabbit or newborn baby), we try to find its position for $0.7C$ times randomly, where C is the number of cells in the grid. A rabbit tries to move to an adjacent cell 10 times, if it fails because of collisions, it remains in place. The level of color brightness of the cell determines the amount of grass on the cell, i.e. the darker the cell is the more grass it has. Finally, the simulation finishes when the last rabbit dies.

Our simulation can overwrite values of input parameters to handle boundary conditions if the values make the simulation poorly defined. Such parameters are the following:
- Number of initial rabbits, number of initial grass and grass growth rate need to be non-negative. If a negative value is an input, it is overwritten to 0 instead.
- Values of baby life span, birth frequency and agent min energy need to be positive. If a non-positive value is an input, it is overwritten to 1 instead.
- The value of agent max energy must be greater or equal than the value of agent min energy. If it is not the case, agent max energy is set to agent min energy.
- Values of birth-giving loss needs to be a real value between 0 and 1. If the number is not in the interval, it is set to 1.

2 Results

2.1 Experiment 1

2.1.1 Setting

The motivation for the first experiment is to find the values of parameters such that the simulation is stable. In other words, that the rabbits will not die out or overpopulate.

	Init rabbits	Init grass	Grass rate	Loss	Freq	Threshold	Baby's E	Min E	Max E
set 1	20	10	30	0.3	20	51	40	30	50
set 2	100	10	30	0.3	20	51	40	30	50
set 3	5	10	30	0.3	20	51	40	30	50
set 4	20	100	30	0.3	20	51	40	30	50

Table 1: The parameter values for the experiment 1: Stable simulations

2.1.2 Observations

For set 1, the population size slightly increases over time and reaches the equilibrium point. Because simulation keeps running indefinitely it needs to be stopped manually. The results are the following:

	Average lifetime	Average babes born per rabbit	Population size	Simulation duration [s]
set 1	210.24179	0.99965	50 011	9150.2215

Table 2: The observation values for the experiment 1: Stable simulation

Similarly, for sets 2, 3, and 4, the simulation is also run indefinitely. However, the number of rabbits and the amount of grass oscillates a lot in the beginning but becomes stable over time. The plots that show number of rabbits for sets 2 and 3 over time are shown on the pictures below.

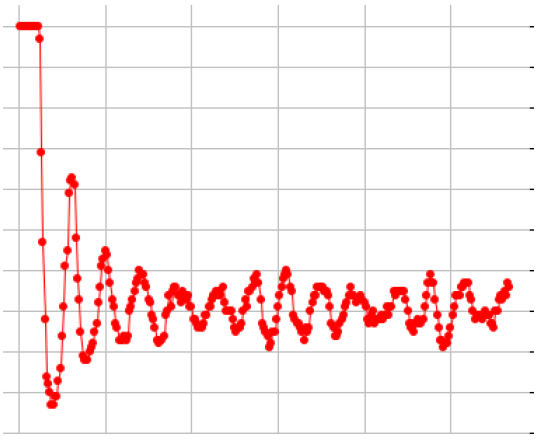

Figure 1: Rabbit population over time with the initial number of rabbits equal to 100 (set 2)

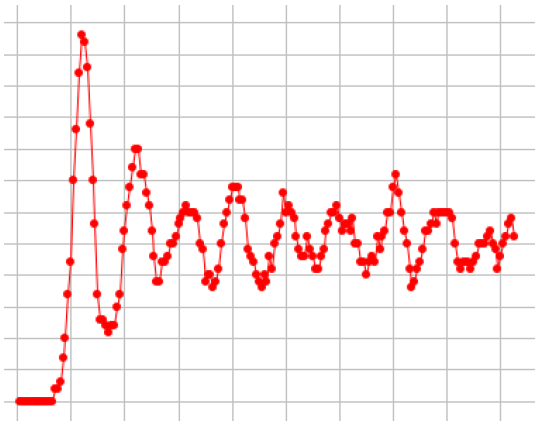

Figure 2: Rabbit population over time with the initial number of rabbits equal to 5 (set 3)

In conclusion, all these parameter combinations lead to stable simulations. Even though the initial number of rabbits and the amount of grass are greatly varied they don't affect much the stability of the simulation.

2.2 Experiment 2

2.2.1 Setting

In this experiment, the goal is to vary specific parameters that cause the simulation to end quickly. The set 5 has a lower grass rate than in previous sets. The set 6 has different interval for the minimum and maximum initial energy of the rabbits and, therefore, the corresponding energy of a baby rabbit. Lastly, in set 7 there is an increased number of rabbits, higher reproduction chances, and decreased growth rate.

	Init rabbits	Init grass	Grass rate	Loss	Freq	Threshold	Baby's E	Min E	Max E
set 5	20	10	10	0.3	20	51	40	30	50
set 6	20	10	30	0.3	20	51	7	5	10
set 7	100	10	10	0.3	1	41	40	30	50

Table 3: The parameter values for the experiment 2: Rabbits dying out

2.2.2 Observations

In the case of set 5, the population dies out quickly because rabbits do not have enough grass to eat and gain energy. Although for set 6 the grass rate is high, rabbits live short due to their low initial energy. The parameters from set 7 show that higher initial numbers of rabbits, lower birth frequency, and birth threshold allow the rabbits to reproduce at each step if they can and make the grid populated quickly. Hence, the rabbits start dying out due to the lack of energy resources provided by the lower grass growth rate.

2.3 Experiment 3

2.3.1 Setting

The effect of grass growth rate is inspected in this experiment.

	Init rabbits	Init grass	Grass rate	Loss	Freq	Threshold	Baby's E	Min E	Max E
set 8	100	10	30	0	1	1	40	30	50
set 9	1	10	30	0.3	100	1000	7	5	10

Table 4: The parameter values for the experiment 2: Rabbits dying out

2.3.2 Observations

In set 8, the idea of overpopulation is tried by setting a high initial number of rabbits and low reproduction rates. In contrast, the idea of under-population is represented in set 9 where there is only one rabbit at the beginning of the simulation and the chances for reproduction are aggravated by increased threshold and birth frequency. Even though the parameters seem insufficient in the long term, the grass growth rate is able to make up for their deficiency and simulations become stable in time.

To conclude, within parameter ranges tried in our simulations, the grass growth rate has the most significant impact on simulation stability.