Università degli Studi di Pavia

Bachelor degree in Artificial Intelligence

Planisuss — Final exam project — A.Y. 2022/23

Stefano Ferrari

Computer programming, Algorithms and Data str., Mod. 1

Contents

date: January 16, 2023
version: 0.5

The final exam project consists in the design and implementation of a simulation of a fictitious world called "Planisuss", freely inspired by Wa-Tor [1][2] and Conway's Game of Life [3][4]. The simulation is intended to provide data to be interactively visualized using the library `matplotlib` [5] (see Sect. 6.1). In order to allow some flexibility in the design, the specifications below described will refer to the simulation parameters through suitable constants, summarized in Sect. 5.

The Planisuss world is constituted of a single continent which is populated by three species: Vegetob, Erbast, and Carviz. In the simulation, several individuals of the species interact evolving their population under the rules explained in the next sections.

1. The Planisuss world

Planisuss is regularly structured in geographical units called *cells*. Cells are organized in a regular grid structure and their position can be identified by a bidimensional coordinate.

The size of Planisuss is `NUMCELLS` $\times$ `NUMCELLS` cells.

The cells can be occupied by water or ground. Cells on the boundary are always occupied by water. All the other cells are suitably assigned either to water or ground at the beginning of the simulation.

Each ground cell can host individuals of the three species, while water cells are uninhabitable. A suitable procedure initialize the content of the cells at the beginning of the simulation.

All the Erbast in a cell constitute a herd. Similarly, all the Carviz in a cell constitute a pride.

2. The ecosystem

Three species populates Planisuss:

Vegetob (*pl.* Vegetob) is a vegetable species. Spontaneously grows on the ground with a regular cycle. Vegetob is the nutrient of Erbast.

Erbast (*pl.* Erbast) is a herbivore species. Erbast eat the Vegetob. Can move on the continent to find better living conditions. Individuals can group forming a *herd*.

Carviz (*pl.* Carviz) is a carnivore species. Carviz predate Erbast. Can move on the continent to find better living conditions. Individuals can group forming a *pride*.

Erbast and Carviz are animal species.

2.1. Vegetob

Vegetob are characterized by their density in a cell. The density can have a value between 0 and 100.

2.2. Erbast

Erbast are characterized by the following properties:

- Energy: represents the strenght of the individual. It is consumed for the activities (movement and fight) and can be increased by grazing. When the energy value reaches 0, the Erbast dies.
- Lifetime: duration of the life of the Erbast expressed in days. Its value is set at the birth and does not change.
- Age: number of days from birth. When the age reaches the lifetime values, the individual terminates its existence.
- Social attitude: measures the likelihood of an individual to join to a herd. It is represented by a value in [0, 1].

Erbast have knowledge about the status of the cells around its position up to a distance of `NEIGHBORHOOD` cells.

2.3. Carviz

Carviz are characterized by the following properties:

- Energy: represents the strenght of the individual. It is consumed for the activities (movement and fight) and can be increased by hunting. When the energy value reaches 0, the Carviz dies.
- Lifetime: duration of the life of the Carviz expressed in days. Its value is set at the birth and does not change.
- Age: number of days from birth. When the age reaches the lifetime values, the individual terminates its existence.
- Social attitude: measures the likelihood of an individual to join to a pride. It is represented by a value in [0, 1].

Carviz have knowledge about the status of the cells around its position up to a distance of `NEIGHBORHOOD` cells.

3. A day on Planisuss

The time on Planisussis structured in units called day. A day is articulated in the following phases:

Growing The Vegetob grows everywhere of a fixed quantity (1 unit).

Movement The individuals of animal species (Erbast and Carviz) decide if move in another area. Movement is articulated as individual and social group (herd or pride) movement.

Grazing Erbast which did not move, can graze the Vegetob in the area.

Struggle Carviz insisting on the same area can fight or hunt.

Spawning Individuals of animal species can generate their offsping.

Conventionally, long periods of time on Planisuss are measured in years, decades and centuries, where a year is 100 days long, a decade is 10 years long, and a century is 10 decades long.

3.1. Growing

The Vegetob density is increased by 1. If a cell is completely surrounded by cells having the maximum Vegetob density, the animals present in the cell are overwhelmed by the Vegetob and terminated.

3.2. Movement

In the Movement phase, individuals and social groups evaluate the possibility to move in another cell. Based on suitable rules, the most appealing cell in the neighborhood is identified. The evaluation is carried on first by social group basis (herd and pride).

All the Erbast in a cell at the beginning of the day belong to a herd. Similarly, all the Carviz in a cell constitute a pride. Social groups can have memories and strategies: proper values can be stored and used in the evaluation and planning. For instance, they can be provided with the coordinate of the last cell visited to avoid to move back, or the density of nutrients of cells visible in previous days.

Once the herd and the pride of the cell made a decision (stay or move), the individuals can choose if they will follow the social group or made a different decision, splitting by the social group. Splitting decision can be formed considering the properties of the individual (e.g., the herd will move, while the individual has a low value of energy) and is weighted with the social attitude of the individual.

Movements take place for all the cells at the same time and are istantaneous. The movement costs to each individual one point of Energy.

3.3. Grazing

The Erbast that did not move, can graze to increment their Energy. The grazing decreases the Vegetob density of the cell. Every Erbast can have 1 point of Energy for 1 point of Vegetob density. If the Vegetob density is lower than the number of Erbast 1 point is assigned to those Erbast having the lowest value of Energy, up to exhaustion of the Vegetob of the cell.

3.4. Struggle

After the movements, the social groups in the cells may need to be reorganized. In fact, different social groups of the same species can reach the same cell.

Erbast in the cell joint to the same herd. If two or more herds moves in the same cell, the herds are fused (and their memories can be joined).

If more than a Carviz pride reach the cell, they evaluate the join in a single pride. The evaluation is made on pride-basis, using the social attitude of their members. If one of the prides decide not to join, a fight takes place. In case of more than two prides reaching the same cell, the above procedure is applied iteratively to pairs of prides (i.e., starting from those with less individuals).

Fight

The fight between two prides is a last-blood match. In its simplest form, a random number is drawn and each pride has a winning probability proportional to the sum of the Energy on its components.

A more complex scheme may consider one-to-one matches between the champions of the pride (those having the higher Energy), until one of the prides has no more components.

Hunt

When only one pride is present in the cell, a hunt takes place. The pride identifies the stronger Erbast in the cell and combat with him. Similarly to the fight, several scheme can be adopted:

- No combat: The prey is always took down. No Energy consumption for the pride.
- Single assault: The pride has only one opportunity to take down the prey. A random number is drawn and the probability of success depends on the relative value of the cumulative Energy of the pride and the Energy of the prey.
- Last blood: The single assault scheme is repeated, but every fruitless assault costs some Energy to the pride (e.g., one Energy from a random individual).

In case of success, the Energy of the prey is shared by the pride individuals, increasing their energy value (spare energy points are assigned to the Carviz with the lowest energy).

3.5. Spawning

The Spawning is the last phase of the day. The Age value of the animals are increased by one day.

Those that reach an age multiple of 100 (one year) have their Energy decreased by 1.

Those that reach their Lifetime are terminated by spawning two offsprings. The offsping properties are set with the following rules:

- Age: set to 0.
- Energy: the sum of the energy of the offspring is equal to the energy of the parent.
- Other properties: the average of the properties of the offsprings are equal to the corresponding properties of the parent.

4. Data visualization

- Overall map
  Images can be used.
  Color channels:
  - R: predators
  - G: preys
  - B: water/vegetable density

  - zoom

- Populations vs time (plot)
  - Numerosity
  - Properties
- Trajectories
- Run/stop
- Cell inspection
  - Optionally: day phase events

Logging of populations properties

- numerosity
- average properties

5. Constants

In this section, some parameters that characterize the simulation are reported as constants. Their values should be chosen to customize the dynamics of the designed simulation. Referring to them in the code allows to modify easily the overall dynamics of the simulation. A proposal for an implementation of these parameters is further described in Sect. 6.2.

`NUMCELLS`: Size of matrix representing the Planisuss map. It is the number of elements in each row and each column. A possible variant may consider a rectangular map, represented as a `NUMCELLS_R` $\times$ `NUMCELLS_C` matrix.

`NEIGHBORHOOD`

6. Resources

6.1. The `matplotlib` library

`matplotlib` is a free and open-source cross-platform library for ... using Python [5].

6.2. Constants

The value of the constants described in Sect. 5 should be chosen accordingly to several factors. For instance, the size of the sprites can suggest the value of the geometric parameters (the contrary is also valid: the sprites can be created to fit some geometrical constraints). The game dynamics modality (real-time vs. turn-based) can condition the time dependent parameters (e.g., training time, speed of the units).

References

[1] A. K. Dewdney, "Computer recreations: Sharks and fish wage an ecological war on the toroidal planet wa-tor," *Scientific American*, vol. 251, pp. 14–22, December 1984.

[2] "Wa-tor." `https://en.wikipedia.org/wiki/Wa-Tor`.

[3] M. Gardner, "The fantastic combinations of John Conway's new solitaire game "life"," *Scientific American*, vol. 223, pp. 120–123, October 1970.

[4] "Conway's game of life." `https://en.wikipedia.org/wiki/Conway%27s_Game_of_Life`.

[5] "Matplotlib website." `https://matplotlib.org/`.