PROJECT DOCUMENTATION

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

Name	WatorPlus	**Date**	27/04/2023
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HIGHLIGHTS

- Addition of Jellyfishes.
- Addition of Kelps.
- Updated movement.
- New display mode.
- Addition of Settings.

INTRODUCTION

The final project consists in the design and implementation of a simulation of a fictitious world called “WatorPlus”, freely inspired by Wa-Tor. Wa-Tor (Alexander K. Dewdney) is a simulation based on a discrete model of predator-prey interaction. It simulates the hypothetical toroidal Planet Wa-Tor (Water Torus) whose surface is entirely covered with water, occupied by two species: fish and sharks. Both sharks and fish live according to a strict set of rules. The simulation is intended to provide data to be interactively visualized using the MATPLOTLIB library , with support from the NUMPY library.

THE WATORPLUS WORLD

WatorPlus is structured with a grid that as dimension GRID_SIZE x GRID_SIZE. The initial number of SHARKS, FISHES and JELLYFISHES will spawn based on the given values by the user and they will have random coordinates (X,Y) at the begginning of the simulation. Unlike the Original Wa-tor, there are no cells. This means that if a point in the grid is already occupied by an object, then another one can pass through it. Given the variable MAX_INTERATIONS, kelps will spawn in the grid in a periodic way. The basic events on WatorPlus happen in discrete time units called ITERATIONS. The goal of Sharks and Fishes is to survive, therefore there are 3 possible outcome:

1) All fishes die.

2) All Sharks die.

3) There will be a balance situation where everyone continues to live .

The simulation will end right after either all Sharks or all Fishes are dead.

ECOSYSTEM

There are a total of 4 characters that populates the simulation: Sharks, Fishes, Jellyfishes and Kelps.

SHARKS

They are predators of the WatorPlus world and their only goal is to hunt and eat fishes, while reproducing. They have the following charateristics:

- **STAMINA**: Based on the amount of STAMINA they can reproduce and continue to live. If the STAMINA reaches a value lower or equal than 0, then the shark will die.
- **X**: It is the value that rapresents the X coordinate in the grid. It is used to compute the x direction, right or left based on the toroidal distance.
- **Y**: It is the value that rapresents the Y coordinate in the grid. It is used to compute the direction, up or down based on the toroidal distance.

Sharks will die if they will step into jellyfishes, they always knew which fish is the closest to hunt and don't know where the jellyfishes are.

FISHES

They are preys of the WatorPlus world and their goal is to swim away from sharks, while trying to eat kelps to reproduce. They have the following charateristics:

- **X**: It is the value that rapresents the X coordinate in the grid. It is used to compute the x direction, right or left based on the toroidal distance.
- **Y**: It is the value that rapresents the Y coordinate in the grid. It is used to compute the direction, up or down based on the toroidal distance.

Fishes don't have stamina to balance the fact that they are slower then sharks, they always know which shark and kelp are the closest and can decide whether to swim away from a shark or go eat a kelp.

JELLYFISHES

They are meant to be an obstacle to sharks, as if they are toxic to them. They are in fact the only animal that can kill a shark. They have the following charateristics:

- **X**: It is the value that rapresents the X coordinate in the grid. It is used to compute the x direction, right or left based on the toroidal distance.
- **Y**: It is the value that rapresents the Y coordinate in the grid. It is used to compute the direction, up or down based on the toroidal distance.

They cannot reproduce, cannot be killed and will move randomly on the grid (will not aim to kill a shark).

KELPS

They are meant to be food for preys. They have the following charateristics:

- **X**: It is the value that rapresents the x coordinate in the grid.
- **Y**: It is the value that rapresents the y coordinate in the grid.

They don't move and will spawn randomly after the number of iterations reaches MAX_ITERATIONS.

ECOSYSTEM LIMITS

Due to the fact that the representation of the scatter function to represent lot of elements with different color and size could be very slow, there are some limits to establish in the simulation.

- **Characters limit:** By default, the value of MAX_CHARACTERS is set to 200. It's the optimal limit to make sure to not suffer slowdowns.
- **Grid size limit.** By default, the value of MIN_GRIDSIZE is set to 100 and MAX_GRIDSIZE is set to 1000. If the grid is too large the characters would be too small to be visualized.

TIME ON WATORPLUS

Each task on WatorPlus is carried out by the pass of each iterations, which can be consider as if a day passed. An iteration is articulated in the following phase:

- **Moving**: All the animals move in the grid to carry out a task, except kelps.
- **Eating**: Either a shark eat fishes or a fish eat kelps.
- **Spawning**: Either sharks or fishes gives birth or a group of kelps spawn.
- **Despawing**: If a shark hit a jellyfish, a fish is eaten by a shark or a kelp is eaten by a fish, they die.

MOVING

Movement works different for each animal. A shark knowing the distance of the closest fish, goes straight hunting it with a speed that can increase depending on the distance. A fish instead has to chose where to go depending on the distance of a shark. It can either escape sharks or go eating kelps. Jellyfishes don't have a direction, they just randomly move on the grid as if they are just floating.

EATING

Eating is essential to Predators and Preys so that they can reproduce. The stamina of a shark is increased each time a fish is eaten and once it has reached a specific threshold, a shark gives birth to another shark losing an amount of stamina. Due to the fact that Preys do not have stamina, they can reproduce once they have eaten a specific amount of kelps.

SPAWNING

Once the user has chosen the settings, the firsts characters spawn randomly at the start of the simulation. Then everytime a Predator or Prey is born, they spawn alongside its parent. A different mechanism happen for kelps. They spawn everytime NUM_ITERATIONS reaches MAX_ITERATIONS. The first row of kelps spawn randomly on the grid, then all the following rows spawn based on the X values of the kelps of the previous row.

VISUALIZATION

To visualize the simulation MATPLOTLIB has been used alongside the help of NUNMPY library. Instead of using cells to represent the world, scatter plots have been used to better visualize the simulation and distinguish the characters that lives in it.

- Sharks are red circle and bigger then everyone else.
- Fishes are blue and small dots.
- Jellyfishes are pink and small circle.
- Kelps are green and small square.

Based on the size of the grid GRID_SIZE every element is inversely proportional (i.e. the more large is the grid the more small are the characters). TKINTER and CUSTOMTKINTER have also been used to display some messages and allow the user to set N_SHARK, N_FISH, N_JELLY and GRID_SIZE before the start of the simulation. In particular, CUSTOMTKINTER as been used to implement the GUI of the settings, while TKINTER was used to display info and warning messages (That's because CTk doesn't contain message boxes).

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.

- **GRID_SIZE**: It's the size of the grid, the toroidal map of the simulation.
- **N_SHARK**: it's the number of sharks that spawn at the start of the simulation.
- **N_FISH**: it's the number of fishes that spawn at the start of the simulation.
- **N_JELLY**: it's the number of jellyfishes that spawn at the start of the simulation.
- **SHARK_SIZE**: It's the value that gives to sharks scatters the size of sharks.
- **FISH_SIZE**: It's the value that gives to fishes, jellyfishes and kelps scatters the size of fishes.
- **MAX_ITERATIONS**: It's the value that NUM_ITERATIONS has to reach so that kelps can spawn.
- **NUM_KELP**: It's the number of kelps that could possibly spawn together.
- **ADJACENT_MIN**: It's the minimum number that a row of kelps might have.
- **ADJACENT_MAX**: It's the maximum number that a row of kelps might have.

RESOURCES

MATPLOTLIB

MATPLOTLIB is an open source Python library used for creating static, animated, and interactive visualizations in Python. It is a popular data visualization library that provides a variety of plots and charts for data analysis and presentation.

NUMPY

NUMPY is a popular open-source Python library used for scientific computing and data analysis. It provides a powerful N-dimensional array object, as well as useful functions for manipulating arrays and performing mathematical operations on them.

TKINTER

TKINTER is a standard Python UI-library used for creating graphical user interfaces (GUIs). It provides a set of tools and widgets for building desktop applications, including buttons, menus, text boxes, and canvas elements for drawing graphics.

CUSTOMTKINTER

CUSTOMTKINTER is a python UI-library based on Tkinter, which provides new, modern and fully customizable widgets. They are created and used like normal Tkinter widgets and can also be used in combination with normal Tkinter elements.

POSSIBLE IMPROVEMENTS

To improve the simulations it could be added:

- The age of Sharks and Fishes, with the newborns following their parents until they reach a specific age to hunt fishes or eating kelps.
- Direction for Jellyfishes. Instead of just floating, they could follow a specific direction that changes over time after some iterations.
- Spread of kelps. If some kelps are already on the grid, then the ones that will spawn could have a chance to grow alongside an existing set of kelps.
- Sea current, so that fishes could use them to escape from shark.
- More customizable variables in the settings, such as speed, kelps spawn rate, kelps density, stamina for a shark to give birth, kelps needed for fishes to give birth etc.

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