Knowledge & Agent Systems
Assignment 1

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September 11, 2024

1 Exploring Sugarscape

1.1 Turtle Variables

- Sugar: A lower value of initial sugar such as 5[1] causes a steep and quick decline in the population of turtles. A higher amount such as 25[2] causes the same decline to occur more gradually over a longer period of time. The low-level explanation for this behavior is that every tick the turtles consume sugar based on their metabolism and a higher sugar means that this process can repeat for longer;
- Metabolism: A lower metabolism rate such as 1[3] leads to minimal population loss over time, whereas a higher rate, like 4[4], results in a significantly greater population decline, eventually stabilizing at a lower level. The low-level reason for that is that after each tick the turtle's sugar level is its previous sugar level plus the sugar amount in the patch it is located on minus its metabolism. That means that a turtle must have access to sugar sources that can provider an amount of food greater or equal the turtles' metabolism to survive in the long run;
- Vision: A higher vision such as 6[6] makes the turtles get concentrated around the spots where sugar is also concentrated[8] whereas a lower vision such as 1[5] prevent the turtles from getting closer to those areas of high concentration of sugar[7] over time. Besides that, a higher vision prevents a more intense reduction in the population of turtles. The low-level explanation for that is every tick the turtle tries to move to the closest patch with the highest amount of sugar in it so that a higher vision alloys the turtles to view and move to the sports with more sugar which also increases the sugar they have access to preventing their death from starvation.

1.2 Estimating the Carrying Capacity

Running the simulation 20 times[1], it is possible to find that on average 229 turtles can survive stably in the environment.

- Mean: 229;
- Standard deviation: 9,58;
- Number of runs: 20 (1000 ticks each run).

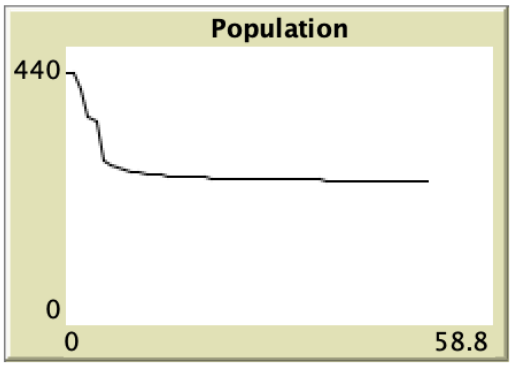

Figure 1: Population distribution when the initial sugar value is set to 5 over 50 ticks.

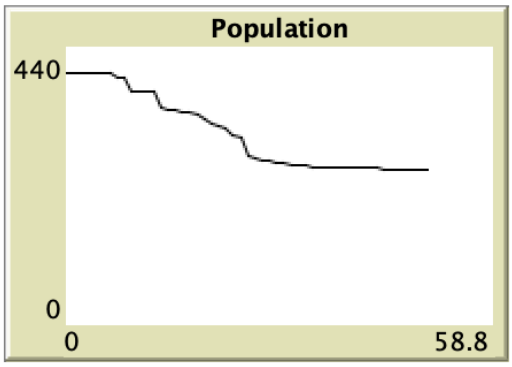

Figure 2: Population distribution when the initial sugar value is set to 25 over 50 ticks.

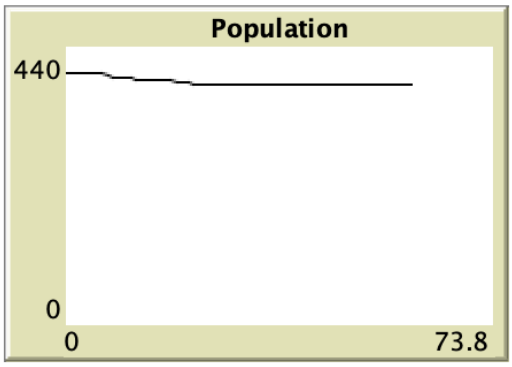

Figure 3: Population distribution when the metabolism is set to 1 over 60 ticks.

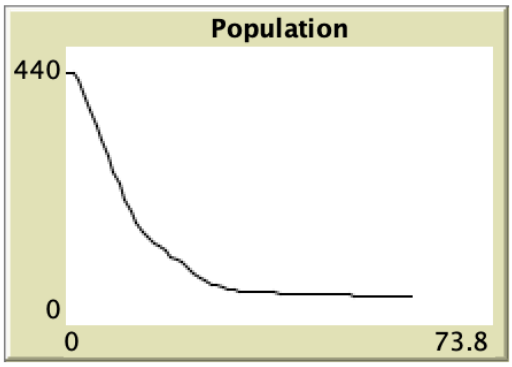

Figure 4: Population distribution when the metabolism is set to 4 over 60 ticks.

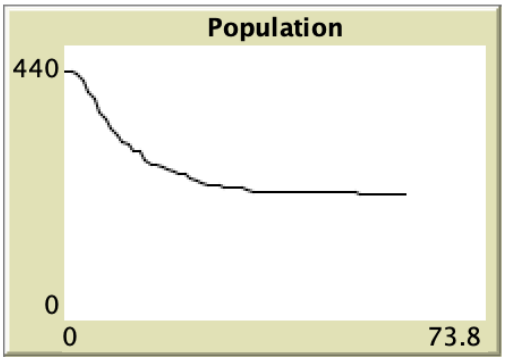

Figure 5: Population distribution when the vision is set to 1 over 60 ticks.

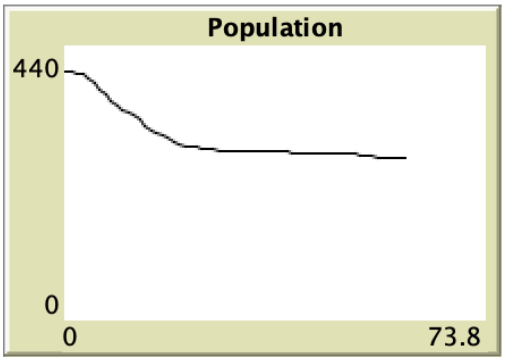

Figure 6: Population distribution when vision is set to 6 over 60 ticks.

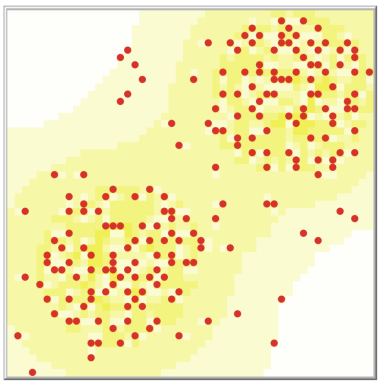

Figure 7: Turtles position when the vision is set to 1 over 60 ticks.

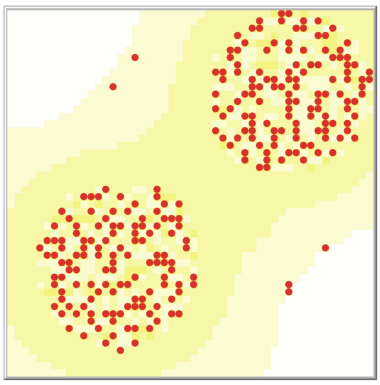

Figure 8: Turtles position when vision is set to 6 over 60 ticks.

Run N°	Carrying Capacity
1	232
2	237
3	241
4	218
5	233
6	230
7	231
8	243
9	219
10	233
11	214
12	240
13	227
14	229
15	248
16	228
17	223
18	220
19	222
20	215

Table 1: Carrying Capacity for 20 Runs

2 Sugarscape, in theory

2.1 Reactivity vs. Proactivity

Turtles in Sugarscape lean heavily toward reactive behavior, because their decisions are based on immediate sensory input (sugar levels on patches within their vision). However, there are some minor elements of proactivity such as their ability of using their vision to anticipate better positions

(with more sugar) which is a very short-term kind of planning, though.

2.2 BDI

- **Beliefs (B)**: The turtles believe in the sugar levels on nearby patches, their own metabolism, their sugar reserves, and their vision range.
- **Desires (D)**: Their main objective is to survive by acquiring enough sugar to stay alive, with a subgoal of maximizing sugar intake.
- **Intentions (I)**: Turtles intend to move to the patch with the most sugar and consume it, ensuring they maintain sufficient sugar reserves to avoid starvation.

2.3 Agents? or Objects?

Even though the turtles are agents and act according to their BDI, they look much more like objects. That can be explained by the reactive nature of the turtles, which means that they do not have much autonomy in deciding how to act and end up executing the same predefined behavior just like an object would do when requested to execute a method.

3 Create Your Own Society

3.1 Emergence?

To initialize the turtles in the third quadrant, code was added for when the value of the global variable "initial-location" is "third-quadrant". Fundamentally, the code adds two conditions for a turtle to be initialized in a patch: the pxcor and pycor values being both below 25 which are the possible values of coordinates in this quadrant. Fallback in the case of enough space not being available for all the turtles was not implemented to make it clear to the user that the population of turtles has exceeded the maximum amount.

```
initial-location = "third-quadrant"
[
  ;; implement this block for Exercise 3.1
  move-to one-of patches with [
    not any? other turtles-here
    and pxcor < 25
    and pycor < 25
  ]
]
```

The emergent behavior that could be noticed is that when the initial population of turtles is low enough, such as 50^9, the turtles move towards the sugar hotspot in the third quadrant and stay there because the sugar provided by the quadrant is enough to provide for that population. When the population size is larger, such as 400^{10}, the turtles also move towards the sugar hotspot in the third quadrant, but as time goes by, there is a migration movement towards the sugar hotspot in the second quadrant, because as the sugar gets depleted in the third quadrant, turtles proactive behaviour is enabled, and they start exploring the map until some of then find the other sugar hotspot.

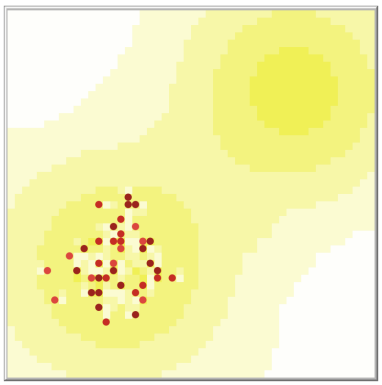

Figure 9: Turtles position when the population is set to 50 over 2000 ticks.

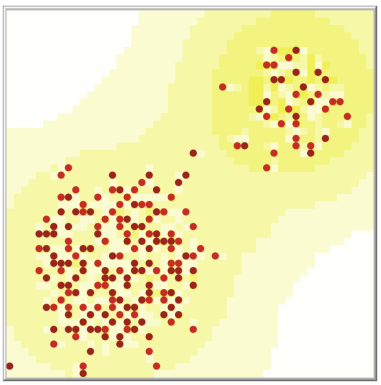

Figure 10: Turtles position when the population is set to 400 over 2000 ticks.

3.2 Socializing Agents

Just like humans, turtles will have the ability to do charity(if "is-sharing" is enabled) in their communities(turtles in their field of view). They will try to donate all the sugar they do not need to survive at least a tick without eating to those turtles in need, which don't have sugar enough to do the same.

```
to turtle-share ;; turtle procedure
  ;; implement this procedure yourself for Exercise 3.2

  ;; Turtles give to charity only when they have got more sugar than they need to
    survive one tick without eating
  if sugar > (metabolism + 1) [
    let nearby-turtles turtles-on patches at-points vision-points

    ;; The maximum amount they give is the sugar exceeding their metabolism + 1 (
    minimum to survive a tick without eating)
    let max-charity-amount sugar - (metabolism + 1)

    ;; They try to donate the sugar to the turtles in their field of view(community)
    ;; Only turtles that do not have enough sugar to survive a tick can receive
    donations
    let turtles-in-need nearby-turtles with [sugar < (metabolism + 1)]

    if any? turtles-in-need [

      let charity-amount 0

      ;; The turtle tries to donate sugar enough for each turtle benefited to survive
     a tick without eating anything
      ask turtles-in-need [
        set charity-amount charity-amount + metabolism - sugar + 1
        ifelse charity-amount < max-charity-amount[
          set sugar metabolism + 1
        ]
        [
          set sugar metabolism + 1 - (max-charity-amount - charity-amount)
          set charity-amount max-charity-amount
          stop
```

```
        ]
      ]

      ;; Updates the sugar amount of the charitable turtle
      set sugar sugar - charity-amount

    ]
  ]

end
```

Simulating 1000 individuals for 2000 ticks 10 times each[2], the implementation of charity between turtles[11] could support 469 individuals compared to 445 in a normal scenario[12]; the population stabilized more gradually when charity was enabled. There was no spatial distribution change identified. In terms of wealth distribution, it was noticed that when charity is enabled, consistently, the only wealth brackets that would keep existing were the "really wealth" and the "poor" with the disappearance of what could be considered a middle class in the normal scenario.

Run Nº	Carrying Capacity (Socializing)	Carrying Capacity (Not Socializing)
1	483	467
2	460	468
3	465	459
4	467	438
5	485	429
6	449	452
7	477	436
8	449	425
9	468	434
10	487	440
Mean	**469**	**445**

Table 2: Carrying Capacity (Socializing vs. Not Socializing)

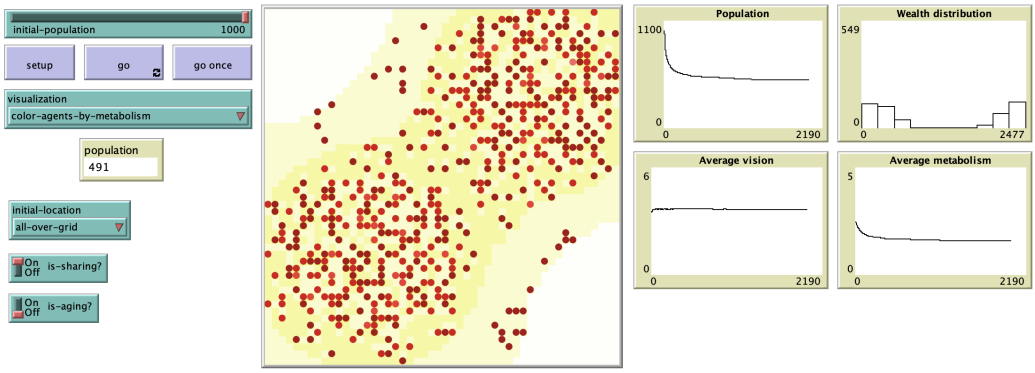

Figure 11: 1000 socializing turtles interface tab over 2000 ticks.

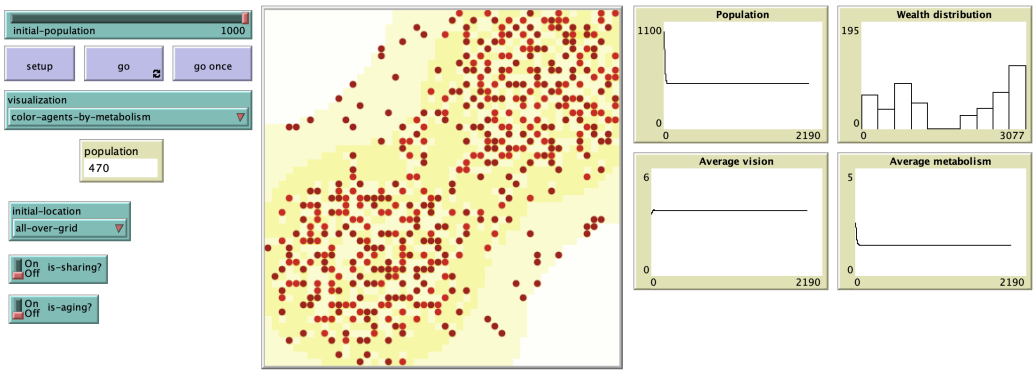

Figure 12: 1000 non-socializing turtles interface tab over 2000 ticks.

3.3 Aging Agents

To implement aging two properties have added to the turtles: age and max-age. "age" monitors the age of the turtle and "max-age" is initialized with a random life expectancy that rages from 60 to 100 ticks. That approach was chosen, because those properties are unique to each turtle. That way, each tick, the age is increased by one and every turtle that dies is substituted by a new one keeping the population stable.

```
max-age          ;; the life expectancy this turtle has
age              ;; the age this turtle has
```

```
set max-age random-in-range 60 100
set age 0
```

```
ifelse is-aging? ;; Using a switch as a global variable for Exercise 3.3
[
  ;; Implement this block and add code elsewhere for Exercise 3.3
  if age >= max-age [ die ] ;; turtle dies of natural reasons
  set age age + 1
]
```

```
if is-aging? [
    create-turtles initial-population - count turtles [ turtle-setup ]
]
```

Analysing the wealth distribution with aging enabled[13], it could be noticed that that the wealth accumulation is much inferior compared to the standard scenario[14]. That can be explained by the fact that turtles have much less ticks to accumulate wealth and new turtles can spawn near them competing for the same sugar resources. Therefore, wealth gets concentrated in the lower brackets.

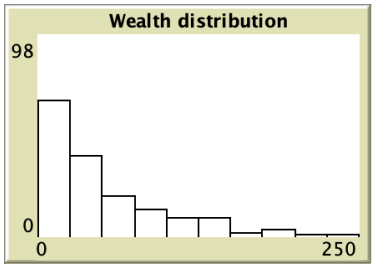

Figure 13: Typical wealth distribution histogram for a population of 250 turtles with aging enabled.

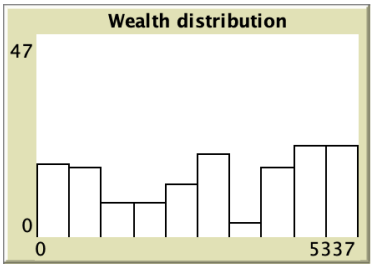

Figure 14: Typical wealth distribution histogram for a population of 250 turtles with aging disabled.