**Project Description**

EcoSim is an application that aims to simulate basic ecosystems. The process starts by generating a randomized terrain. From there, animals will be placed in the simulation. Animal types can be sheep, wolves, bunnies, foxes, and more. The user can choose to let the simulation run on its own, resulting in a completely randomized simulation cycle. The user also has the choice to modify specific aspects of the simulation, such as offspring rate, food growth rate, average lifespan, and much more. The simulation aims to cover a large range of real-world aspects, such as population levels, prey vs. predator, mutations, and much more.

**Competitive Analysis**

Predator-Prey Ecosystem by Wolfram

The Predator-Prey Ecosystem software by Wolfram is a very simple simulation. It focuses heavily on the accuracy of the simulation itself, rather than having a bunch of extra features as well. This system and EcoSim will be similar in that they both display in some way at least one predator and at least one prey, both competing against each other. The two simulations will also be similar in that the user can adjust sliders on the side of the screen, which will have a direct impact on attributes of the simulation. Layout will also be very similar. The two simulations will be different in many ways. First, while EcoSim will strive for an accurate simulation, Wolfram’s will honestly most likely be more accurate since Wolfram is known for their mathematical capabilities. This should be one of, if not the only, key difference between the two where Wolfram’s software has a clear advantage. Second, EcoSim will be much more visually appealing. EcoSim will have actual images for each animal (rather than colored dots), nicer looking sliders, and of course, terrain. Third, EcoSim will be more algorithmically complex in other areas. For example, EcoSim will have randomized terrain generation, featuring bodies of water, grass, bare patches of land, and pretty flowers. Fourth, EcoSim’s animals will have more attributes than Wolfram’s, including offspring rate and even mutations. There are many mutations that will happen in EcoSim. Fifth, EcoSim will have a graph that graphs the current animal populations. Overall, while Wolfram’s software will be highly accurate, EcoSim will be a much better and visually appealing product with far more features.

Wolf Sheep Predation by NetLogo

The Wolf Sheep Predation simulation by NetLogo is much more similar to EcoSim than Wolfram’s simulation. This system and EcoSim will be similar in that they both display the animals using images, graph the current animal populations, feature sliders that impact the simulation, as well as feature basic terrain generation. Algorithmically speaking, the algorithm for how animals interact with each other and the environment will probably be similar in complexity, although there is no way to be sure. NetLogo’s system and EcoSim will be different in that NetLogo allows the user to change the code. This isn’t always a good thing though, especially for the average user. Second, EcoSim features a much more complex algorithm for the terrain generation; NetLogo randomly populates the terrain with either grass and/or bare patches (usually with a ~1:1 ratio), while EcoSim randomizes the amount and placement of the grass, bare patches, and flowers (randomized ratio each time). EcoSim’s terrain generation also features bodies of water. Third, EcoSim will be modernized, and therefore will be more visually appealing. NetLogo’s simulation is very outdated, and therefore looks as old as it is. Fourth, EcoSim’s animal types will have many more attributes than the animals in NetLogo’s simulation do, including water intake levels and the opportunity to mutate. As stated before, EcoSim features wild mutations, such as being diseased, changing size, turning different colors, and even cannibalism. Overall, NetLogo’s simulation and EcoSim are similar, but EcoSim is still a better product.

**Structural Plan**

Animals: Every animal type will share the same core attributes (i.e., each animal will have hunger levels, thirst levels, health levels, offspring rate, mutation rate, etc.). Each animal will inherit these attributes from the parent class, Animal. Each animal type, however, will have their own specific starting attribute values. For example, a sheep’s starting strength levels will be far less than a wolf’s starting strength levels. Each animal type’s class code will also be stored in its own file for organization.

Assets: Each asset for every animal type will be stored in the ‘assets’ directory. Some animal types will have multiple assets, such as one asset for a blue sheep, one asset for a sheep with a specific mutation, one asset for a sheep who’s sick, etc. This is the goal, but I may not be able to reach it in time.

General Code: Most of the code will be stored in main.py. As of right now, the plan is to have all of the code pertaining to the simulation in main.py in what seems like the most intuitive, chronologically-organized way possible.

**Algorithmic Plan**

Animals Interacting in the Ecosystem (very hard)

This will be the hardest, most algorithmically complex feature to implement by far. There are many parts to this system, of which I will list in the order that they must be implemented:

1. Dynamically create instances of animal objects
2. Dynamically display images of the animal objects in the terrain
3. Use pathfinding-like technology that will allow animals to chase after one another, water, food, etc.
4. Create more instances of animal objects when animals have offspring
5. Delete instances of animal objects when they die, and also delete their image from the screen
6. Modify animal attributes on initialization to reflect when an animal has mutated
7. While doing all of this, accurately keep track of each instance’s attributes

Terrain Generation (hard)

This feature will also be algorithmically complex. There will be four main parts to the terrain generation:

1. Grass (which animals can eat)
2. Bare land (when there is nothing there to eat)
3. Flowers (extra-nutritious food)
4. Water (which animals can drink and possibly swim in)

There are currently two possible algorithms for the terrain generation, each one looking something similar to the following pseudocode:

1. Option 1 (the less likely candidate)
   1. Generate a 2D list with dimensions equal to the dimensions of the grid we will be generating. Randomly populate this list with the colors ‘green’ (grass), ‘tan’ (no grass), ‘pink/red/purple’ (flowers), ‘blue’ (water).
   2. Draw a grid by drawing the cells one by one (like we did in the case studies). Each cell will correspond to an element in the 2D list we generated. That way each cell will also have a color associated to it.
      1. At this stage, we have a grid with a completely randomized terrain. Nothing looks good or makes sense.
   3. To make it look nicer, we have to group the water together into bodies of water. This is how we do that: while drawing each cell, if we run into a blue cell, we look at all of the surrounding cells a few times, and if they are valid placements, we also make those cells blue. Then we have a cohesive body of water.
      1. We would only do this 2-3 times, or else most of the grid would be water
   4. The random pink/red/purple cells would represent flowers
2. Option 2 (the much more likely candidate)
   1. Generate a grid with all grass (green cells)
   2. Complete this process 2-3 times
      1. Pick a random cell on the grid
      2. Make it blue
      3. Look at all surrounding cells a random number of layers (this will make the size of the body of water vary each time the simulation is run). If it’s a valid cell, make it blue.
         1. We now have bodies of water
   3. Complete this process a random number of times (0-20 inclusive)
      1. Pick a random cell on the grid
      2. Pick a random color (either ‘pink’, ‘red’, or ‘purple’)
      3. Make that cell that color
         1. We now have flowers
   4. Complete this process a random number of times
      1. Pick a random cell on the grid
      2. If it is green, make it tan
         1. We now have patches of grassless land

Graphing (Average/Easy)

Time allowing, I plan on creating my own graphing system to graph the current population of each animal type. To do this, I would use cmu\_112\_graphics to plot lines based off of the current data of each animal type (this is average in difficulty). If I run out of time, I will use matplotlib (easy in difficulty).

User Interaction (sliders impact the simulation) (Easy)

This feature shouldn’t be hard to implement, but it could be time consuming. As the user adjusts sliders on the right-hand side of the screen, the simulation should also change. For example, if the user changes ‘grass growth rate’ to 1, then the grass will grow back much slower than if the slider were at 10. The sliders will be coded from scratch, rather than using a module that has sliders built in. This will somewhat help increase algorithmic complexity. This process will work as so:

1. Create text that will act as the label for each slider
2. Create a line that the slider will ‘slide’ on
3. Create a rectangle that will rest on the line and act as the slider
4. If the user drags the slider, it will slide along the same x-axis and it will not go off of the line
5. Update the number/variable associated with that slider

There are currently two possible approaches on how to implement the feature where the slider directly impacts the simulation:

1. Option 1 (the less likely candidate)
   1. Each slider will be linked to a variable. That variable will change the simulation live
2. Option 2 (the more likely candidate, strictly due to time constraints)
   1. Each slider will be linked to a variable. The sliders can only be changed *before* the simulation is run. The sliders cannot be modified during the simulation, and therefore the simulation cannot be changed live.

**Timeline Plan**

Complete by 8:00 PM on November 18, 2021

* Terrain Generation Part 1 (Bodies of Water)
* Basic slider implementation
* Dynamically initialize animals
* Animals follow each other

Complete by 8:00 PM on November 23, 2021

* Any features I did not finish from the last deadline (hopefully this won’t happen)
* Users can change the simulation by changing the sliders
* Animals are ‘alive’ (i.e., they move, eat, drink, hunt, die, etc.)
* Terrain Generation Part 2 (Flowers)
* Implement all sliders
* Mutation
* Graphing

Complete by 5:00 PM on December 1, 2021

* Any features I did not finish from the last deadline (hopefully this won’t happen)
* TP Video
* Fun ideas for after MVP is reached
  + Optimization
  + More mutations
  + More animal types
  + Climate Change
  + Humans cutscene-like feature

**Version Control Plan**

All files are being backed up to GitHub. I already have a repo (currently public so that my mentor, Asad, can look at the ideas I've come up with) that is currently storing all versions of my code.

A screenshot of a computer

Description automatically generated with medium confidence

**Modules**

I will be using cmu\_112\_graphics. One feature I would like to implement requires graphing. Time allowing, I will use cmu\_112\_graphics and code my own graphing software. If I run out of time, I will use matplotlib. I won’t know whether I will use matplotlib until I know how much time I have to implement this feature.

**TP2 Update**

Each slide (excluding the title screen) has been flipped. For example, instead of the simulation grid being on the right-hand side of the screen, it is now on the left-hand side of the screen. Instead of the sliders being on the left-hand side of the screen, they are now on the right-hand side of the screen. This made the math for the simulation grid easier. When there is no simulation running, the grid now also is semi-greyed out with text overlayed on it that says “No Simulation Running.” Lastly, there is now an “End Simulation” button that ends the current simulation. Because of this, the graph had to be slightly moved up from where it is shown in the storyboard. No other major changes were made.

**TP3 Update**

One major change was made during TP3. Before TP3, the positions of the animals were in terms of pixels. This made development very hard and tedious, and it also made implementing new features (such as sheep-detection for the wolves) ***incredibly*** difficult. During the development phase for TP3, I changed this so that animal positions are now in terms of row and col. This made implementing new features ***significantly*** easier, which is why I was able to make as much progress as I did this last week. There were also some minor design changes, such as making the graph larger on the screen, disabling the sliders while a simulation is running (signified by greying out the sliders during a running simulation), having the grass grow back after it has been eaten by a sheep, and allowing up to a combined total of 150 animals on the screen at once (where it previously was only a combined total of 20 animals at once).