SECTION I.

Modeling of the experimental part

Genetic algorithms apply a generalized evolutionary loop to optimize the fitness of an organism (Ashlock, 1998). In a genetic algorithm, every solution in a population is represented as a gene or data structure. This gene carries all of the relevant information that can be altered by the algorithms. The initial population of solutions may be random or pre-initialized with possible very “fit” solutions. The fitness evaluation is done according to a given fitness function which maps data structures onto some ordered set.

The process of natural selection starts with the selection of fittest individuals from a population. They produce offspring which inherit the characteristics of the parents and will be added to the next generation. If parents have better fitness, their offspring will be better than parents and have a better chance at surviving. This process keeps on iterating and at the end, a generation with the fittest individuals will be found.

This notion can be applied for a search problem. We consider a set of solutions for a problem and select the set of best ones out of them.

Five phases are considered in a genetic algorithm.

1. Initial population
2. Fitness function
3. Selection
4. Crossover
5. Mutation

A. Virtual Environment and Animated Agents

The virtual environment consisted of 1200 x 600 2D screen, “bloops” as the creatures that are the representation of a living form and rectangles as food sources for the bloops.

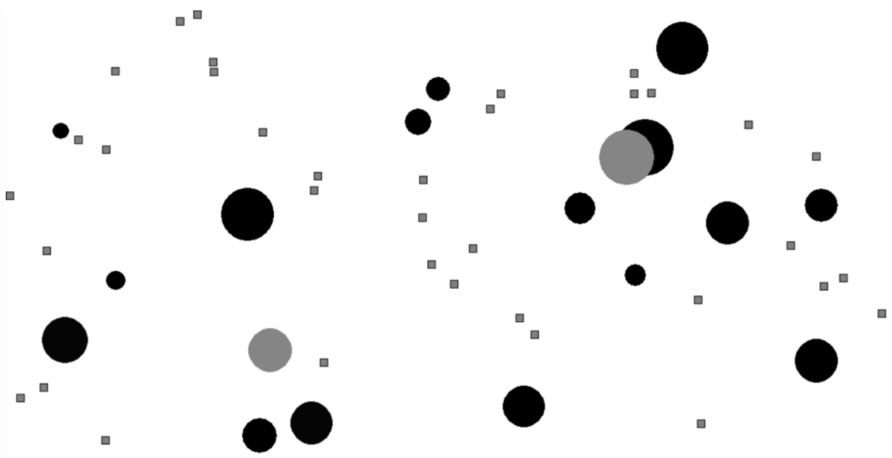

Figure 1. Image with the environment of the bloops that chase the food

The *Bloops* – have the form of a circle. The creatures' movements are generated using Perlin Noise and a speed from the interval [-x, x] where x is the maximum speed set by the user. The size is inversely proportional to the speed: the bigger the bloop, the slower it is. When a bloop eats a rectangle, it reduces its hunger and improves its fitness by 1. They have a starting health which is declining as time passes, and it can improve by eating. For the visual effect, the less health a bloop has, the whiter it turns until it disappears completely. If a bloop ate once, it survives the next generation. If a bloop ate at least 2 units of food, then it is capable of reproducing. If a bloop didn't eat at all, it dies.

The *Food* – has the form of a rectangle. It gives health and fitness to the bloop. Every iteration, the food quantity is halved.

B. Fitness Function

Fitness Function (also known as the Evaluation Function) evaluates how close a given solution is to the optimum solution of the desired problem. It determines how fit a solution is. Some individuals will compete and those with good fitness will reproduce. What we mean by having good fitness is having the objective function optimized:

$$f(x) = x, \text{ where } x \text{ is how much food units the Bloop ate}$$

We create the equivalent maximization problem as max(f(x)). Even though in genetic algorithms, each solution is generally represented as a string of binary numbers, known as a chromosome, for this experiment for the fitness score the chromosome will be an integer number representing the number of food units eaten.

C. Selection

The idea of selection phase is to select the fittest individuals and let them pass their genes to the next generation. Two pairs of individuals (parents) are selected based on their fitness scores. Individuals with high fitness have more chance to be selected for reproduction.

For this experiment, the *Tournament Selection* is used. Selection is done by taking a sample from the population in the t-th generation for t = 1, 2, …, then from that sample, one individual with the best fitness is selected to continue to enter the population in the (t+1)-st generation. Individuals in the t-th generation who are not selected will die off. This process is carried out multiple times so that the number of individuals in the population in each generation is the same.

D. Crossover

In genetic algorithms and evolutionary computation, crossover, also called recombination, is a genetic operator used to combine the genetic information of two parents to generate new offspring.

For this experiment, the *Blend Crossover Operator* is used. (the variant with $\alpha = 0$). Assuming p1 < p2, this crossover operator creates a random solution in the range [p1, p2].

p1 - first parent

p2 - second parent

u - random number in [0, 1]

offspring = (1 - u) * p1 + u * p2

The blend crossover operator has the interesting property that if the difference between parents is small, the difference between the child and parent solutions is also small. So the spread of current population dictates the spread of solutions in the resulting population (this is a form of adaptation).

E. Mutation

In certain new offspring formed, some of their genes can be subjected to a mutation with a low random probability. Mutation is a genetic operator used to maintain genetic diversity from one generation of a population of genetic algorithm chromosomes to the next.

In this case, the *uniform mutation* is adding or subtracting from the size the value 0.02 and the probability for an individual to mutate is 10%.

F. Validation of results

Triangulation is a research method that involves collecting data from multiple sources in order to get a more complete picture of a phenomenon. In research, triangulation is defined as the use of multiple data sources to investigate a phenomenon. Triangulation can be used in quantitative research, where multiple data sources are used to confirm findings, or in qualitative research, where multiple perspectives are used to gain a deeper understanding of a phenomenon.

I gathered multiple studies and results from researches that compared what I was researching: from both the animal world and applications of this comparison in the human world. For example, for the size VS speed comparison, I researched articles in the domain of sports and from the animal world. From an athletic point of view, the answer is both are extremely important in an athlete's success and are two separate things in training, but work in conjunction for a well-rounded athlete. Each is just as important as the other because athletes need both strength and speed to be competitive in their given sport. From an animal’s point of view, smaller animals tend to have several advantages over large-bodied ones. They need less food and less space. They also tend to breed much faster, producing far more offspring. Keeping this in mind, I expected the results of the experiment to favorize the small to medium bloops over others.

SECTION II.

Research case

I selected a population of 20 bloops and 100 food units. Every iteration lasts 7 seconds, and the number of iterations is 3-5 depending on how much the bloops survive, the maximum number of iterations being 5. The probability for selection, crossover and mutation are 10%, 20% and 100%. Every 40 milliseconds, the bloop is losing health and its maximum health is 255. In the first iteration, the bloops are placed randomly, and after that at each iteration the population starts competing for food from the right bottom corner. The food quantity is halved each iteration.

The question that I am trying to answer is: “Which has the better chance of survival through generations? The *smallest and fastest* or the *biggest and slowest*”? Both have their advantages and disadvantages which will be discussed below.

A. First try

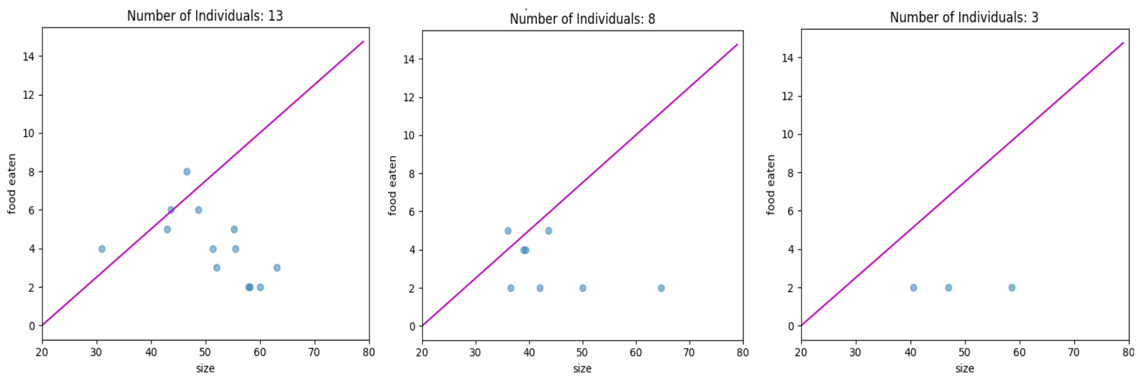

Figure 2. First trial results

The graphics generated by the plotlib package show statistics for bloops that reproduce at the end of an iteration. The size of the surviving interval on the initial iteration is [30,70], indicating that neither the smallest nor the largest bloops were able to persist or procreate in the initial generation. Even though the smallest bloop is the fastest among them all, due to its size, the bloop was passing by nearly every food unit, as it can also be seen from the 2D simulation, despite the fact that its speed helped it to be the first one to have a chance to take the food. The bigger bloops, on the other hand, have a better chance of grabbing the food nearby, but because they move too slowly, other bloops reached the food before them.

The bloops that ate the most are in the interval [40, 50] and the bloops that had a greater chance of survival had the size in the interval [40, 60], which is precisely the middle of our original interval: [20, 80]. This shows that, for the first try, balance is the answer to survival, since both speed and size is important.

B. Second try

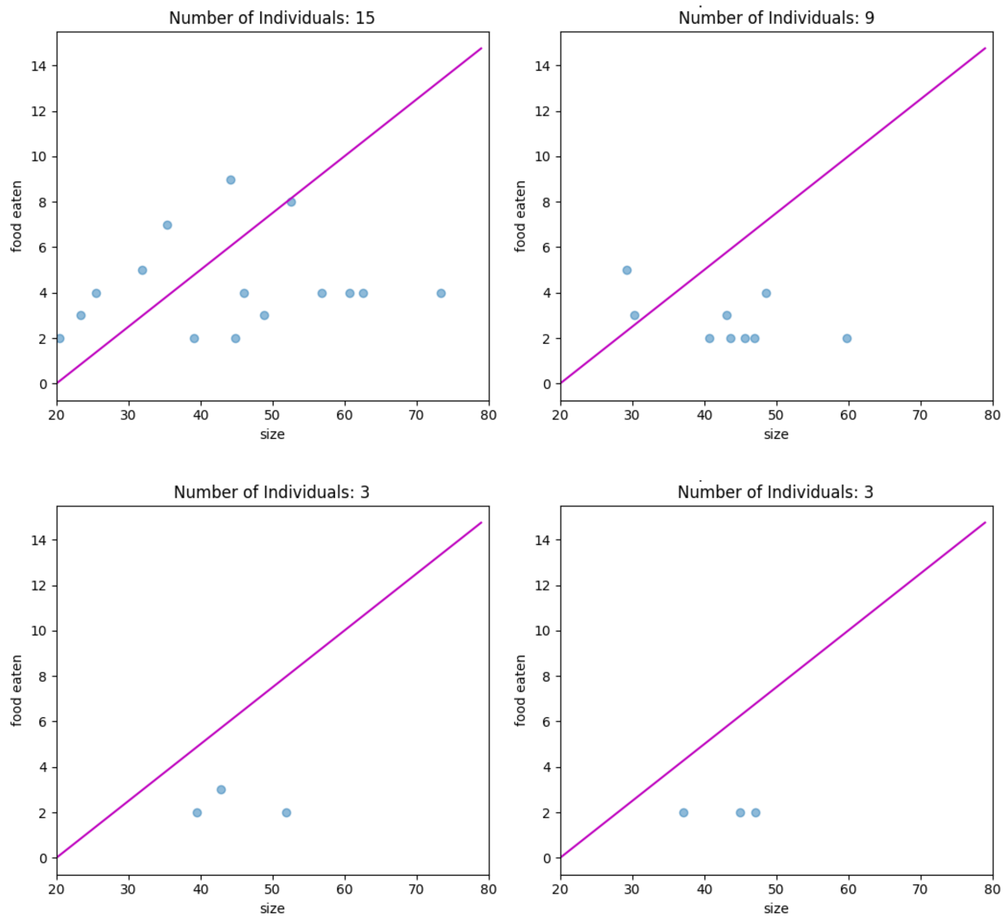

Figure 3. Second trial results

From the second try we can conclude that the smallest to medium bloops survived, the range being [35, 50]. From other trials, the natural selection favored either the medium bloops or the small-to-medium bloops. Also, the number of food units eaten were almost equal in every trial for each size, the bloops being scattered the same and as proof you can compare the images from Figure 2 and Figure 3. This concludes that our hypothesis and validations are correct: you need to have a balance of both speed and size to survive the natural selection.

SECTION III.

Related work

The first similar research found was written by Sterling's Team Speed which is a leader in sports performance training, who compared speed and size in the athletic domain, and concluded that "athletes need both strength and speed to be competitive in their given sport".

The article “Only small animals might stand a chance in a manmade world” by Daniel T Cross highlighted the idea that small creatures will be favored by natural selection. The difference between this research and his is that Daniel T cross included humans as a factor. A lot of other articles found on the internet talked about the intervention of humans and other external factors, while the presented research case strictly focuses on creatures’ growth in their environment over time, without any interventions.

A very similar experiment and research is done by a youtuber which goes by the name “Prism” in his “Simulating Natural Selection” video, where he sees how his “blobs” evolve over time. His experiment has a different disadvantage for the bigger creatures: the bigger creatures consume twice as much energy (so they die faster), while the bigger bloops move slower. His conclusion is the same as mine, which is that creatures of the sizes medium-to-small survive on the long term.

Personally, I expected the conclusion to be on the side of the medium ones, so the fact that the smaller-to-medium ones also survived was an unexpected yet pleasant surprise.

SECTION IV.

History on GitHub

Here is the link of the history of commits:

https://github.com/AliceHincu/Simulation-of-Ecosystem/commits/main

Here is the link of the project:

https://github.com/AliceHincu/Simulation-of-Ecosystem

This is the code for this research