Evolutionary Models with a Large Number of Genes

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Contents

0.1 Introduction

We are simulation a population model, where every creature has a gene and we are investigating the mutations of different genes. This is trying to mimic real life evulation with mutation.

To be continued...

0.2 Methods

Creature

A creature is defined with its genome, position and energy. The genome consists of 5 genes that represent certain characteristics of that creature. The position shows the creature's position in the grid and the energy shows its energy level.

Food

Food are randomly generated when a simulation is initiated and randomly spawns in each timestep, but with a predefined limit.

Energy

A creature starts with predefined base energy level, and dies when the energy level reaches 0. The creatures gains energy by consuming food or winning an attack against another creature, and loses energy when moving.

Attack

A creature has a gene for its level of aggression, which shows how likely it is to initiate an attack. The winner is determined by the strength gene. The winner gains energy, while the loser dies.

Reproduction and Mutations

If a creature gains energy with a certain ratio of its maxmimum energy, it reproduces and gives 1 offspring, and loses a certain ratio of its energy. The offspring is spawned in an adjacent positon and each gene is copied from its parent, with a certain probability for each gene to change by a value of 1.

0.2.1 Memory optimization

The creature is defined as an unsigned 32-bit integer, where the first 16 bits represent the genome, the next 12 bits represent its position cell and the last 4 bits represent the energy.

0.2.2 Energy loss

$$\text{energy loss} = \text{steps} + \left\lceil \frac{\text{eyesight}}{3} \right\rceil + \left\lfloor \frac{\text{aggression}}{5} \right\rfloor + \left\lfloor \sqrt{\text{strength}} \right\rfloor + \left\lfloor \frac{\text{stamina}}{7} + 1 \right\rfloor$$

$$\text{eyesight} \in \{0, 1, ..., 7\}$$

$$\text{aggression} \in \{0, 1, ..., 7\}$$

$$\text{strength} \in \{1, 2, ..., 16\}$$

$$\text{stamina} \in \{-7, -6, ..., 8\}$$

All these values have an effect on how much energy the creature spends. Steps are the number of steps. We have no energy loss from aggression, up until the value of 5.

Gene	Bits	Description
Speed	2	Takes values between 1 and 4, showing the Manhattan distance the creature can walk in a single timestep.
Eyesight	3	Takes values between 0 and 7, showing the Manhattan distance the creature can see.
Aggression	3	Takes values between 0 to 7, mapped to 0% - 100%, showing the probability of the creature attacking another creature in the same cell.
Strength	4	Takes values between 1 and 16, which determines the winner in a fight
Stamina	4	Takes values between -7 and 8, which is added to the base energy level, when generating the creature

Table 1: Creature characteristics and their descriptions

Speed	**Eyesight**	**Aggression**	**Strength**	**Stamina**
0 1	2 3 4	5 6 7	8 9 10 11	12 13 14 15
2 bits	3 bits	3 bits	4 bits	4 bit

Figure 1: Gene storage

The creatures are stored in a list and are iterated over in every timestep.

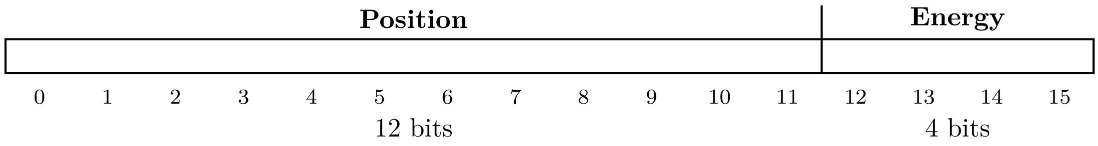


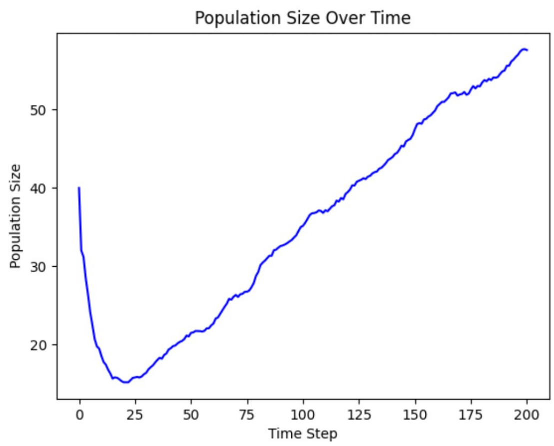
Figure 2: Position storage

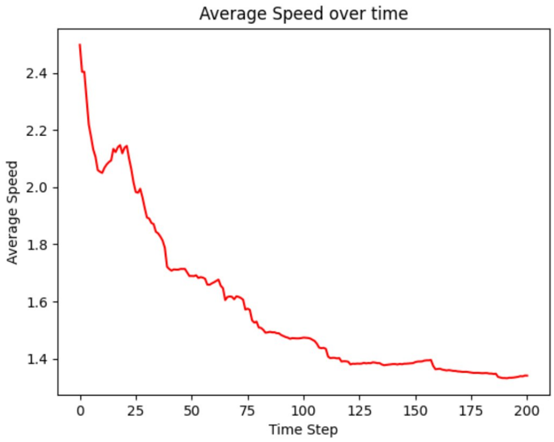
0.3 Results

The following constants were chosen for our simulations:

Constant	Value	Notes
Grid size	64	$2^6 \times 2^6$ grid
Food cap	0.05	5% of the grid
Init creatures	0.01	We start with 1% of the grid being creatures
Steps	10000	Number of timesteps
Base energy	8	Base energy
Energy from food	5	Energy gained from consuming food
Energy from creature	8	Energy gained from consuming another creature
Energy ratio to reproduce	0.9	When energy level reaches 90% of the creatures max energy, it reproduces
Energy ratio for reproduce	0.2	20% of energy is consumed for reproduction
Number of children	1	Each reproduction only produces a single offspring
Mutation probability	0.01	There is a 1% change for each gene to mutate during reproduction

Table 2: Creature characteristics and their descriptions





Code is availabe at https://github.com/suren2003ah7/EvolutionaryModel.

0.4 Discussion

We have simulated the model with several cases, however we may try on more complex cases.

1. Random genes. Try many random genes for creatures and see if we reach equilibrium of one gene.

2. Strong specific genes. Start with high values for specific genes and see if we reach equilibrium or not after mutaitons.

3. Record the evolution of each gene by averaging that genes during each timestep.

References

Roff, D. A. (2008, Dec). Defining fitness in evolutionary models. *Journal of Genetics*, *87*(4), 339–348. doi: 10.1007/s12041-008-0056-9