МИНИСТЕРСТВО НАУКИ И ВЫСШЕГО ОБРАЗОВАНИЯ
РОССИЙСКОЙ ФЕДЕРАЦИИ
ФЕДЕРАЛЬНОЕ ГОСУДАРСТВЕННОЕ БЮДЖЕТНОЕ ОБРАЗОВАТЕЛЬНОЕ УЧРЕЖДЕНИЕ
ВЫСШЕГО ОБРАЗОВАНИЯ
«БЕЛГОРОДСКИЙ ГОСУДАРСТВЕННЫЙ
ТЕХНОЛОГИЧЕСКИЙ УНИВЕРСИТЕТ им. В. Г. ШУХОВА»
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ИНСТИТУТ ИНФОРМАЦИОННЫХ ТЕХНОЛОГИЙ И УПРАВЛЯЮЩИХ СИСТЕМ

Лабораторная работа №6

по дисциплине: Основы искусственного интеллекта
тема: «Моделирование искусственной жизни на основе принципов эволюции Ламарка»

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Белгород 2025 г.

Цель работы: закрепить на практике знания по основам нейронных сетей и моделированию искусственной жизни. Получить навыки анализа поведения агентов в симулированной экосистеме, основанной на наследовании приобретенных признаков (мутации весов нейросети).

Краткое описание модели

Модель представляет собой упрощённую экосистему на тороидальном поле размером 30x30 (MAX_GRID). В ней существуют два типа агентов: травоядные (HERBIVORE) и плотоядные (CARNIVORE), а также растения (PLANT). Каждый агент управляется простой нейронной сетью прямого распространения без скрытых слоёв.

Схема нейронной сети агента:

1. Входы: 12 сенсорных значений — количество травоядных, плотоядных и растений в секторах обзора (спереди, слева, справа, в непосредственной близости).
2. Скрытые слои: Отсутствуют (прямая связь от входов к выходам).
3. Выходы: 4 действия — поворот налево, поворот направо, движение вперёд, съесть.
4. Веса: Инициализируются случайно, передаются потомкам с мутацией (один вес изменяется с вероятностью 0.2).
5. Активация: Winner-takes-all — выбирается действие с максимальным значением на выходе.

Жизненный цикл агента (в функции simulateAgent):

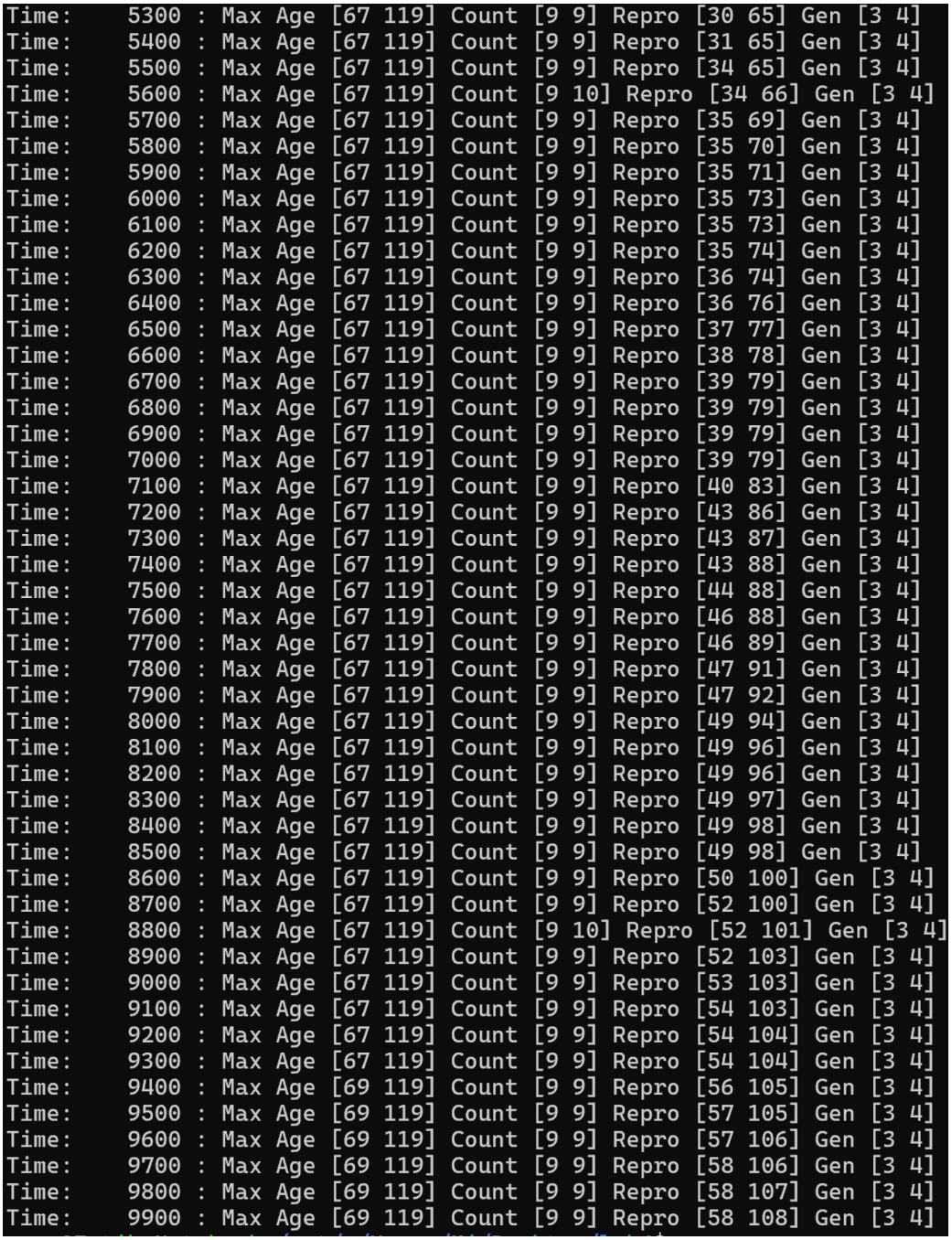
1. Восприятие (percept): Заполнение входного вектора на основе позиции, направления и окружающих объектов (с учётом тороидальности поля).
2. Принятие решения: Прямое распространение через сеть (сумма входов * веса + bias), выбор действия.
3. Выполнение действия: Поворот (turn), движение (move) или поедание (eat).
4. Метаболизм: Уменьшение энергии (травоядные -2, плотоядные -1 за шаг). Если энергия ≤0, агент погибает (killAgent).
5. Размножение: Если энергия > 0.9 * MAX_ENERGY (54), и популяция < MAX_AGENTS/2 (18), создаётся потомок с мутацией (reproduceAgent).

Эволюция по Ламарку: Приобретённые веса (оптимизированные через выживание) передаются потомкам с мутацией, имитируя наследование приобретённых признаков.

Ход работы

Эксперимент 1 (Эволюция): Запуск без флагов (./sim)

```
user@Entik-Notebook:/mnt/c/Users/Mi/Desktop/lab6$ ./sim
Time:       0 : Max Age [1 1] Count [18 18] Repro [0 0] Gen [0 0]
Time:     100 : Max Age [22 71] Count [9 9] Repro [1 0] Gen [2 0]
Time:     200 : Max Age [29 89] Count [9 10] Repro [2 1] Gen [2 2]
Time:     300 : Max Age [31 89] Count [9 9] Repro [2 3] Gen [2 3]
Time:     400 : Max Age [31 89] Count [9 9] Repro [2 6] Gen [2 3]
Time:     500 : Max Age [31 89] Count [9 9] Repro [3 6] Gen [2 3]
Time:     600 : Max Age [31 89] Count [9 9] Repro [3 7] Gen [2 3]
Time:     700 : Max Age [39 89] Count [9 9] Repro [3 8] Gen [2 3]
Time:     800 : Max Age [50 89] Count [9 9] Repro [4 10] Gen [2 3]
Time:     900 : Max Age [50 89] Count [9 9] Repro [4 10] Gen [2 3]
Time:    1000 : Max Age [52 89] Count [9 9] Repro [4 12] Gen [2 3]
Time:    1100 : Max Age [52 89] Count [9 9] Repro [6 15] Gen [2 3]
Time:    1200 : Max Age [52 89] Count [9 9] Repro [6 18] Gen [2 4]
Time:    1300 : Max Age [52 89] Count [9 9] Repro [6 18] Gen [2 4]
Time:    1400 : Max Age [52 89] Count [9 9] Repro [6 18] Gen [2 4]
Time:    1500 : Max Age [52 89] Count [9 9] Repro [6 21] Gen [2 4]
Time:    1600 : Max Age [52 89] Count [9 9] Repro [7 23] Gen [2 4]
Time:    1700 : Max Age [52 89] Count [9 9] Repro [8 23] Gen [2 4]
Time:    1800 : Max Age [52 89] Count [9 9] Repro [8 23] Gen [2 4]
Time:    1900 : Max Age [52 89] Count [9 9] Repro [11 27] Gen [2 4]
Time:    2000 : Max Age [52 89] Count [9 9] Repro [11 28] Gen [2 4]
Time:    2100 : Max Age [52 89] Count [9 9] Repro [12 28] Gen [2 4]
Time:    2200 : Max Age [52 89] Count [9 9] Repro [12 30] Gen [2 4]
Time:    2300 : Max Age [53 89] Count [9 9] Repro [15 30] Gen [2 4]
Time:    2400 : Max Age [53 89] Count [9 9] Repro [16 30] Gen [2 4]
Time:    2500 : Max Age [53 89] Count [9 10] Repro [17 33] Gen [2 4]
Time:    2600 : Max Age [53 89] Count [9 9] Repro [17 34] Gen [2 4]
Time:    2700 : Max Age [53 89] Count [9 9] Repro [17 34] Gen [2 4]
Time:    2800 : Max Age [53 89] Count [9 9] Repro [18 35] Gen [2 4]
Time:    2900 : Max Age [53 89] Count [9 9] Repro [19 36] Gen [2 4]
Time:    3000 : Max Age [53 89] Count [9 9] Repro [20 38] Gen [2 4]
Time:    3100 : Max Age [53 89] Count [9 9] Repro [22 38] Gen [2 4]
Time:    3200 : Max Age [53 89] Count [9 9] Repro [22 38] Gen [2 4]
Time:    3300 : Max Age [53 89] Count [9 9] Repro [22 38] Gen [2 4]
Time:    3400 : Max Age [53 89] Count [9 9] Repro [22 38] Gen [2 4]
Time:    3500 : Max Age [53 89] Count [9 9] Repro [22 38] Gen [2 4]
Time:    3600 : Max Age [53 89] Count [9 11] Repro [23 45] Gen [2 4]
Time:    3700 : Max Age [53 89] Count [9 9] Repro [23 46] Gen [2 4]
Time:    3800 : Max Age [53 89] Count [9 9] Repro [23 48] Gen [2 4]
Time:    3900 : Max Age [53 89] Count [9 9] Repro [24 48] Gen [2 4]
Time:    4000 : Max Age [53 89] Count [9 9] Repro [24 49] Gen [2 4]
Time:    4100 : Max Age [53 89] Count [9 9] Repro [24 49] Gen [2 4]
Time:    4200 : Max Age [53 89] Count [10 9] Repro [26 50] Gen [3 4]
Time:    4300 : Max Age [53 89] Count [9 9] Repro [26 51] Gen [3 4]
Time:    4400 : Max Age [53 90] Count [9 9] Repro [27 52] Gen [3 4]
Time:    4500 : Max Age [53 90] Count [9 9] Repro [28 53] Gen [3 4]
Time:    4600 : Max Age [67 90] Count [9 9] Repro [28 55] Gen [3 4]
Time:    4700 : Max Age [67 90] Count [9 9] Repro [29 55] Gen [3 4]
Time:    4800 : Max Age [67 90] Count [9 9] Repro [29 57] Gen [3 4]
Time:    4900 : Max Age [67 90] Count [9 9] Repro [29 58] Gen [3 4]
Time:    5000 : Max Age [67 119] Count [9 9] Repro [29 61] Gen [3 4]
Time:    5100 : Max Age [67 119] Count [9 9] Repro [29 64] Gen [3 4]
Time:    5200 : Max Age [67 119] Count [9 9] Repro [30 64] Gen [3 4]
Time:    5300 : Max Age [67 119] Count [9 9] Repro [30 65] Gen [3 4]
```



Динамика популяций: Начально 18 травоядных и 18 плотоядных. К 100 шагам популяции стабилизировались в большенстве на 9/9. Максимальный возраст травоядных вырос до 69, плотоядных — до 119. Размножения: травоядные до 58, плотоядные до 108. Поколения: 3/4.

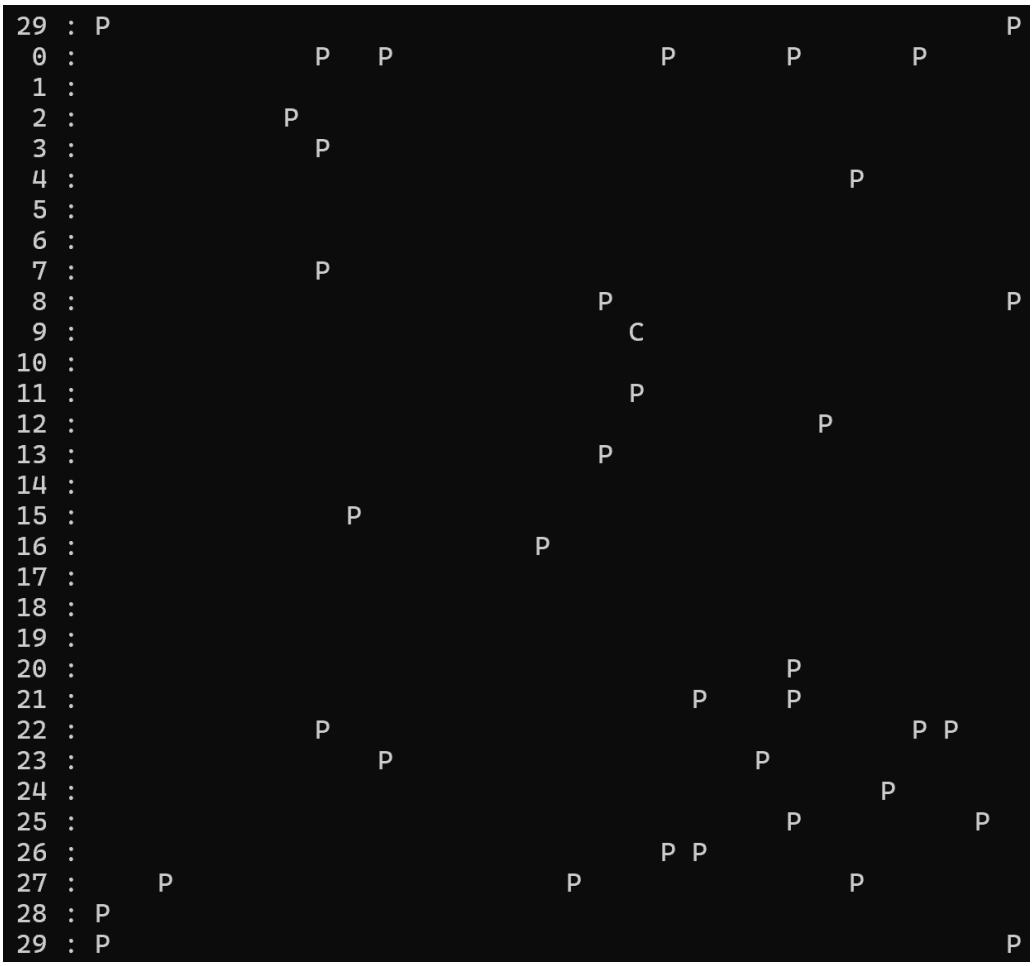
Наблюдение: Естественный отбор — агенты с "удачными" весами живут дольше, размножаются чаще. Популяции балансируют из-за ограничений энергии и пространства.

Эксперимент 2 (Воспроизведение): Запуск с флагом -p (./sim -p).

Загружены лучшие агенты из agents.dat. Поведение: Травоядные активно ищут растения (P), избегают плотоядных (C), двигаются к пище. Плотоядные преследуют травоядных, едят их. Растения статичны, но исчезают при поедании и регенерируют в стандартном режиме. Агенты поворачивают, чтобы ориентироваться на цель.

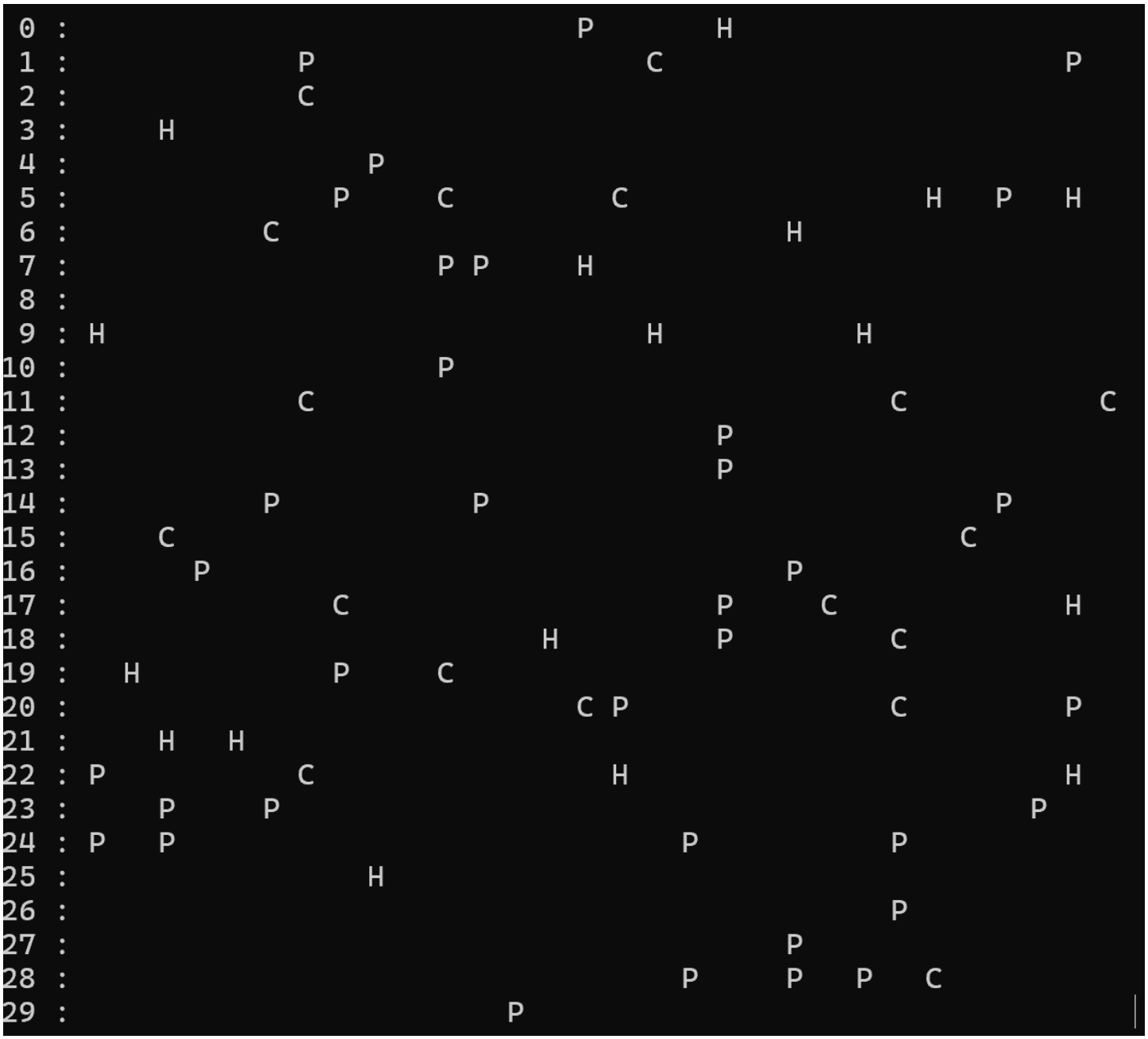
Качественное описание: "Умные" агенты эффективны — травоядные быстро находят растения, плотоядные охотятся целенаправленно, избегая бесполезных движений.

Визуализация: Агенты перемещаются, поедают, размножаются; плотоядные доминируют над травоядными в охоте.



Видим, что остались только растения и один плотоядный. Это связано с тем, что травоядные съедают растения, размножаются, плотоядные съедают травоядных и тоже размножаются. Растения заканчиваются, травоядные вымирают от голода и поедания плотоядными. Плотоядные вымирают от голода. Через время растения регенерируют.

Включим пошаговый режим (добавим флаг -s) и совершим 5 шагов



С -n (запрет размножения, ./sim -n): Размножения =0, поколения =0. Популяции быстро падают до 9/9 и стабилизируются. Максимальный возраст: травоядные 159, плотоядные 233. Экосистема устойчива, но без эволюции — агенты не улучшаются, вымирание медленное (агенты живут долго за счёт случайных весов).

```
Time:       0 : Max Age [1 1] Count [16 18] Repro [0 0] Gen [0 0]
Time:     100 : Max Age [37 89] Count [9 9] Repro [0 0] Gen [0 0]
Time:     200 : Max Age [52 89] Count [9 9] Repro [0 0] Gen [0 0]
Time:     300 : Max Age [52 89] Count [9 9] Repro [0 0] Gen [0 0]
Time:     400 : Max Age [52 119] Count [9 9] Repro [0 0] Gen [0 0]
Time:     500 : Max Age [52 119] Count [9 9] Repro [0 0] Gen [0 0]
Time:     600 : Max Age [52 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:     700 : Max Age [52 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:     800 : Max Age [52 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:     900 : Max Age [52 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    1000 : Max Age [52 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    1100 : Max Age [52 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    1200 : Max Age [52 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    1300 : Max Age [53 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    1400 : Max Age [67 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    1500 : Max Age [67 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    1600 : Max Age [67 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    1700 : Max Age [67 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    1800 : Max Age [67 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    1900 : Max Age [67 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    2000 : Max Age [67 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    2100 : Max Age [67 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    2200 : Max Age [123 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    2300 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    2400 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    2500 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    2600 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    2700 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    2800 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    2900 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    3000 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    3100 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    3200 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    3300 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    3400 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    3500 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    3600 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    3700 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    3800 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    3900 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    4000 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    4100 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    4200 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    4300 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    4400 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    4500 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    4600 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    4700 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    4800 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    4900 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    5000 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    5100 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    5200 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    5300 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    5400 : Max Age [159 179] Count [9 9] Repro [0 0] Gen [0 0]
Time:    5500 : Max Age [159 233] Count [9 9] Repro [0 0] Gen [0 0]
Time:    5600 : Max Age [159 233] Count [9 9] Repro [0 0] Gen [0 0]
Time:    5700 : Max Age [159 233] Count [9 9] Repro [0 0] Gen [0 0]
Time:    5800 : Max Age [159 233] Count [9 9] Repro [0 0] Gen [0 0]
Time:    5900 : Max Age [159 233] Count [9 9] Repro [0 0] Gen [0 0]
Time:    6000 : Max Age [159 233] Count [9 9] Repro [0 0] Gen [0 0]
```

С -g (запрет роста растений, ./sim -g): Растения не регенерируют (исчезают после поедания). Травоядные размножаются мало (repro=2, gen=2, max age=37) — умирают от голода. Плотоядные процветают (repro до 275, gen=15, max age=248, count 9/10), поедая травоядных. Популяции: травоядные 9, плотоядные растут/падают. Экосистема неустойчива — травоядные вымирают быстрее, за ними начнут плотоядные.

```
user@Entik-Notebook:/mnt/c/Users/Mi/Desktop/lab6$ ./sim -g
Time:       0 : Max Age [1 1] Count [18 18] Repro [0 0] Gen [0 0]
Time:     100 : Max Age [37 101] Count [9 9] Repro [1 1] Gen [2 2]
Time:     200 : Max Age [37 118] Count [9 10] Repro [1 2] Gen [2 2]
Time:     300 : Max Age [37 118] Count [9 10] Repro [1 5] Gen [2 2]
Time:     400 : Max Age [37 118] Count [9 9] Repro [1 8] Gen [2 4]
Time:     500 : Max Age [37 118] Count [9 9] Repro [1 10] Gen [2 4]
Time:     600 : Max Age [37 118] Count [9 9] Repro [1 11] Gen [2 4]
Time:     700 : Max Age [37 118] Count [9 9] Repro [2 11] Gen [2 4]
Time:     800 : Max Age [37 118] Count [9 9] Repro [2 11] Gen [2 4]
Time:     900 : Max Age [37 118] Count [9 9] Repro [2 12] Gen [2 4]
Time:    1000 : Max Age [37 118] Count [9 9] Repro [2 13] Gen [2 4]
Time:    1100 : Max Age [37 118] Count [9 9] Repro [2 14] Gen [2 4]
Time:    1200 : Max Age [37 118] Count [9 9] Repro [2 15] Gen [2 4]
Time:    1300 : Max Age [37 118] Count [9 9] Repro [2 17] Gen [2 4]
Time:    1400 : Max Age [37 118] Count [9 9] Repro [2 17] Gen [2 4]
Time:    1500 : Max Age [37 118] Count [9 9] Repro [2 18] Gen [2 4]
Time:    1600 : Max Age [37 118] Count [9 9] Repro [2 20] Gen [2 4]
Time:    1700 : Max Age [37 118] Count [9 9] Repro [2 21] Gen [2 4]
Time:    1800 : Max Age [37 118] Count [9 10] Repro [2 25] Gen [2 5]
Time:    1900 : Max Age [37 118] Count [9 9] Repro [2 27] Gen [2 5]
Time:    2000 : Max Age [37 119] Count [9 9] Repro [2 30] Gen [2 5]
Time:    2100 : Max Age [37 119] Count [9 10] Repro [2 41] Gen [2 6]
Time:    2200 : Max Age [37 136] Count [9 15] Repro [2 52] Gen [2 7]
Time:    2300 : Max Age [37 155] Count [9 9] Repro [2 57] Gen [2 7]
Time:    2400 : Max Age [37 166] Count [9 9] Repro [2 59] Gen [2 7]
Time:    2500 : Max Age [37 166] Count [9 9] Repro [2 59] Gen [2 7]
Time:    2600 : Max Age [37 166] Count [9 10] Repro [2 68] Gen [2 7]
Time:    2700 : Max Age [37 166] Count [9 9] Repro [2 68] Gen [2 7]
Time:    2800 : Max Age [37 166] Count [9 9] Repro [2 69] Gen [2 7]
Time:    2900 : Max Age [37 166] Count [9 9] Repro [2 71] Gen [2 7]
Time:    3000 : Max Age [37 166] Count [9 9] Repro [2 77] Gen [2 7]
Time:    3100 : Max Age [37 166] Count [9 9] Repro [2 79] Gen [2 7]
Time:    3200 : Max Age [37 166] Count [9 9] Repro [2 80] Gen [2 7]
Time:    3300 : Max Age [37 166] Count [9 9] Repro [2 81] Gen [2 7]
Time:    3400 : Max Age [37 166] Count [9 9] Repro [2 83] Gen [2 7]
Time:    3500 : Max Age [37 166] Count [9 9] Repro [2 87] Gen [2 7]
Time:    3600 : Max Age [37 166] Count [9 9] Repro [2 88] Gen [2 7]
Time:    3700 : Max Age [37 166] Count [9 10] Repro [2 91] Gen [2 7]
Time:    3800 : Max Age [37 166] Count [9 9] Repro [2 94] Gen [2 7]
Time:    3900 : Max Age [37 166] Count [9 9] Repro [2 94] Gen [2 7]
Time:    4000 : Max Age [37 166] Count [9 9] Repro [2 94] Gen [2 7]
Time:    4100 : Max Age [37 166] Count [9 9] Repro [2 95] Gen [2 7]
Time:    4200 : Max Age [37 166] Count [9 9] Repro [2 96] Gen [2 7]
Time:    4300 : Max Age [37 166] Count [9 9] Repro [2 96] Gen [2 7]
Time:    4400 : Max Age [37 166] Count [9 9] Repro [2 99] Gen [2 7]
Time:    4500 : Max Age [37 166] Count [9 11] Repro [2 106] Gen [2 7
Time:    4600 : Max Age [37 166] Count [9 10] Repro [2 114] Gen [2 7
Time:    4700 : Max Age [37 168] Count [9 9] Repro [2 116] Gen [2 7]
Time:    4800 : Max Age [37 168] Count [9 9] Repro [2 117] Gen [2 7]
Time:    4900 : Max Age [37 168] Count [9 9] Repro [2 121] Gen [2 7]
Time:    5000 : Max Age [37 168] Count [9 9] Repro [2 122] Gen [2 7]
Time:    5100 : Max Age [37 168] Count [9 9] Repro [2 125] Gen [2 7]
Time:    5200 : Max Age [37 168] Count [9 9] Repro [2 127] Gen [2 7]
Time:    5300 : Max Age [37 168] Count [9 9] Repro [2 134] Gen [2 7]
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```
Time:    5000 : Max Age [37 168] Count [9 9] Repro [2 122] Gen [2 7]
Time:    5100 : Max Age [37 168] Count [9 9] Repro [2 125] Gen [2 7]
Time:    5200 : Max Age [37 168] Count [9 9] Repro [2 127] Gen [2 7]
Time:    5300 : Max Age [37 168] Count [9 9] Repro [2 134] Gen [2 7]
Time:    5400 : Max Age [37 168] Count [9 9] Repro [2 136] Gen [2 7]
Time:    5500 : Max Age [37 168] Count [9 9] Repro [2 136] Gen [2 7]
Time:    5600 : Max Age [37 168] Count [9 9] Repro [2 136] Gen [2 7]
Time:    5700 : Max Age [37 168] Count [9 10] Repro [2 137] Gen [2 7]
Time:    5800 : Max Age [37 168] Count [9 9] Repro [2 143] Gen [2 7]
Time:    5900 : Max Age [37 168] Count [9 9] Repro [2 144] Gen [2 7]
Time:    6000 : Max Age [37 168] Count [9 9] Repro [2 144] Gen [2 7]
Time:    6100 : Max Age [37 168] Count [9 9] Repro [2 145] Gen [2 7]
Time:    6200 : Max Age [37 168] Count [9 9] Repro [2 146] Gen [2 7]
Time:    6300 : Max Age [37 168] Count [9 9] Repro [2 147] Gen [2 7]
Time:    6400 : Max Age [37 168] Count [9 9] Repro [2 147] Gen [2 7]
Time:    6500 : Max Age [37 168] Count [9 9] Repro [2 147] Gen [2 7]
Time:    6600 : Max Age [37 168] Count [9 9] Repro [2 148] Gen [2 7]
Time:    6700 : Max Age [37 168] Count [9 9] Repro [2 152] Gen [2 7]
Time:    6800 : Max Age [37 168] Count [9 9] Repro [2 152] Gen [2 7]
Time:    6900 : Max Age [37 168] Count [9 9] Repro [2 152] Gen [2 7]
Time:    7000 : Max Age [37 168] Count [9 9] Repro [2 155] Gen [2 7]
Time:    7100 : Max Age [37 168] Count [9 9] Repro [2 156] Gen [2 7]
Time:    7200 : Max Age [37 168] Count [9 9] Repro [2 157] Gen [2 7]
Time:    7300 : Max Age [37 168] Count [9 9] Repro [2 158] Gen [2 7]
Time:    7400 : Max Age [37 168] Count [9 9] Repro [2 158] Gen [2 7]
Time:    7500 : Max Age [37 168] Count [9 9] Repro [2 159] Gen [2 7]
Time:    7600 : Max Age [37 168] Count [9 9] Repro [2 159] Gen [2 7]
Time:    7700 : Max Age [37 168] Count [9 9] Repro [2 162] Gen [2 7]
Time:    7800 : Max Age [37 168] Count [9 10] Repro [2 170] Gen [2 7]
Time:    7900 : Max Age [37 168] Count [9 10] Repro [2 182] Gen [2 10]
Time:    8000 : Max Age [37 195] Count [9 10] Repro [2 194] Gen [2 11]
Time:    8100 : Max Age [37 248] Count [9 13] Repro [2 216] Gen [2 14]
Time:    8200 : Max Age [37 248] Count [9 9] Repro [2 226] Gen [2 15]
Time:    8300 : Max Age [37 248] Count [9 9] Repro [2 232] Gen [2 15]
Time:    8400 : Max Age [37 248] Count [9 9] Repro [2 240] Gen [2 15]
Time:    8500 : Max Age [37 248] Count [9 9] Repro [2 246] Gen [2 15]
Time:    8600 : Max Age [37 248] Count [9 9] Repro [2 251] Gen [2 15]
Time:    8700 : Max Age [37 248] Count [9 9] Repro [2 253] Gen [2 15]
Time:    8800 : Max Age [37 248] Count [9 9] Repro [2 254] Gen [2 15]
Time:    8900 : Max Age [37 248] Count [9 9] Repro [2 256] Gen [2 15]
Time:    9000 : Max Age [37 248] Count [9 10] Repro [2 264] Gen [2 15]
Time:    9100 : Max Age [37 248] Count [9 9] Repro [2 265] Gen [2 15]
Time:    9200 : Max Age [37 248] Count [9 9] Repro [2 266] Gen [2 15]
Time:    9300 : Max Age [37 248] Count [9 9] Repro [2 266] Gen [2 15]
Time:    9400 : Max Age [37 248] Count [9 9] Repro [2 267] Gen [2 15]
Time:    9500 : Max Age [37 248] Count [9 9] Repro [2 267] Gen [2 15]
Time:    9600 : Max Age [37 248] Count [9 9] Repro [2 269] Gen [2 15]
Time:    9700 : Max Age [37 248] Count [9 10] Repro [2 272] Gen [2 15]
Time:    9800 : Max Age [37 248] Count [9 9] Repro [2 275] Gen [2 15]
Time:    9900 : Max Age [37 248] Count [9 9] Repro [2 275] Gen [2 15]
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Вывод: на лабораторной работе изучены основы нейронных сетей в моделировании искусственной жизни, проанализировано поведение агентов. Наблюдаемые эволюционные процессы: Мутация весов приводит к улучшению поведения (дольше жизнь, больше размножений). Достоинства модели: Простота, демонстрация Ламарка, визуализация. Недостатки: Нет обучения в реальном времени, упрощённая NN (без скрытых слоёв), фиксированные параметры (энергия, мутация) — может не отражать сложные экосистемы.