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**Abstract**

Text (max 300 words)…

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# Introduction

## Background

The people’s collaboration in the societies can be considered as one of the main aspects of the development in terms of economy, health, education and so on. For example, in a country the citizens would have a better health care system, if all of them pay their taxes. However, it is always possible that some of people can bypass the rules and stop paying it. There are different approaches to address this issue for example, a government can deprive those who do not pay their taxes from welfare system benefits or another way can be educating people in a way that it works based on trust.

In this regard, there are some practices to simulate the real societies using small group of men and women and test their way of collaboration. For instance, one of these experimental economics is “public goods game”. In this game the participants are given equal amount of money and there is a public pot that they can put some or all their money. When they put their tokens in the pot, it will be multiplied by a factor and then, it will be divided in the players. So, if a player is careful about the society benefits, he/she will put more money and those who are selfish and only consider their personal benefits will not put anything. The scenario that individuals only think about their personal gain is called “Tragedy of the Commons”.

This problem or tragedy can be discussed in the field of artificial intelligence as well. For example, if we make fisher robots and reward them based on the number of fishes they can bring, they will do it as much as possible and eventually the ecosystem will be damaged. So, maybe we should change their rewarding schema in a way that they must also consider the community benefits and do not ruin the ecosystem. In this study, we are going to work in this problem and check the possibility of forcing artificial agents to cooperate based on their common welfare and not only their individual interest.

## Purpose

Testing artificial agents’ way of collaboration is the general aim of the research. To make the tests, we have defined a game that four artificial agents (which they use Markov Brain) should collaborate and collect grasses in a limited size filled that is surrounded by walls. There are some game’s settings that we estimate should affect their way of group work. The most important one is rewarding scheme which is shown in the next table.

|  |  |
| --- | --- |
| Reward mode | Meaning |
| 0 | Individual reward |
| 1 | Mean score (What they got on average) |
| 2 | Max score (What their best performer received) |
| 3 | Minimum score (What their worst performer received) |

Table Different rewarding schemes of the game

So, we will change the rewarding schemes and other parameters (that will be explained in the methods section) and will check the changes in the agents’ team working approaches.

To make this process clear, we have categorized the way of collaboration as the following table:

|  |  |
| --- | --- |
| Type of collaboration | Collaboration explanation |
| All for one | All of them help the weakest one |
| One for all | All the agents help the leader |
| Average | They perform in a way that they get a good average score |
| Individual | They to their best to just get higher scores |

Table Different types of collaboration

According to the above collaboration categories and the game, the research question is elaborated as:

What is the reaction of artificial agents in different scenarios? Will they use the four type of collaboration system according to changes in the game’s settings such as rewarding scheme?

## Literature review

# Material and Methods

## Data description

*Text…*

## Methods

**Simple example:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  | |  |  |  |  |  | |  |  |  | |  |  |  |  |  | |  |  |  | |  |  |  |  |  | |  |  | Icon  Description automatically generated | | Icon  Description automatically generated | Icon  Description automatically generated | Icon  Description automatically generated |  |  | |  |  |  | |  |  |  |  |  | |  |  |  | |  |  |  |  |  | | Turn 1 Scores | | | | | | | | | | A1 0 | | | A2  0 | | A3  0 | | A4  0 | | | |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  | |  |  |  |  |  | |  |  |  | |  |  |  |  |  | |  |  | Icon  Description automatically generated | |  | Icon  Description automatically generated |  |  |  | |  |  |  | |  |  |  |  |  | |  |  | Icon  Description automatically generated | |  |  |  | Icon  Description automatically generated |  | |  |  |  | |  |  |  |  |  | | Turn 2 Scores | | | | | | | | | | A1  1 | | | A2  0 | | A3  1 | | A4  0 | | | |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  | |  |  |  |  |  | |  | Icon  Description automatically generated |  | |  | Icon  Description automatically generated |  |  |  | |  |  |  | |  |  |  |  |  | |  |  | Icon  Description automatically generated | |  |  |  | Icon  Description automatically generated |  | |  |  |  | |  |  |  |  |  | |  |  |  | |  |  |  |  |  | | Turn 3 Scores | | | | | | | | | | A1  1 | | | A2  0 | | A3  2 | | A4  0 | |   First generation’s genetics: A1: G1 A2: G2 A3: G3 A4: G4  IDs: A1: 1 A2: 2 A3: 3 A4: 4 |
| |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  | |  |  |  |  |  | |  |  |  | |  |  |  |  |  | |  |  |  | |  |  |  |  |  | |  |  | Icon  Description automatically generated | | Icon  Description automatically generated | Icon  Description automatically generated | Icon  Description automatically generated |  |  | |  |  |  | |  |  |  |  |  | |  |  |  | |  |  |  |  |  | | Turn 1 Scores | | | | | | | | | | A1 0 | | | A2  0 | | A3  0 | | A4  0 | | | |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  | |  |  |  |  |  | |  |  |  | |  |  |  |  |  | |  |  |  | | Icon  Description automatically generated |  | Icon  Description automatically generated |  |  | |  |  |  | |  |  |  |  |  | |  | Icon  Description automatically generated |  | |  | Icon  Description automatically generated |  |  |  | |  |  |  | |  |  |  |  |  | | Turn 2 Scores | | | | | | | | | | A1 0 | | | A2  1 | | A3  0 | | A4  1 | |   Second generation’s genetics: A1: G1\*V1 A2: G3\*V2 A3: G3\*V3 A4: G3\*V4  IDs: A1: 5 A2: 6 A3: 7 A4: 8 | |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  | |  |  |  |  |  | |  |  |  | |  |  | Icon  Description automatically generated |  |  | |  |  |  | |  |  |  |  |  | |  | Icon  Description automatically generated |  | |  | Icon  Description automatically generated |  |  |  | |  |  |  | |  |  |  | Icon  Description automatically generated |  | |  |  |  | |  |  |  |  |  | | Turn 3 Scores | | | | | | | | | | A1 0 | | | A2  1 | | A3  0 | | A4  2 | | |
| |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  | |  |  |  |  |  | |  |  |  | |  |  |  |  |  | |  |  |  | |  |  |  |  |  | |  |  | Icon  Description automatically generated | | Icon  Description automatically generated | Icon  Description automatically generated | Icon  Description automatically generated |  |  | |  |  |  | |  |  |  |  |  | |  |  |  | |  |  |  |  |  | | Turn 1 Scores | | | | | | | | | | A1 0 | | | A2  0 | | A3  0 | | A4  0 | | | |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  | |  |  |  |  |  | |  |  |  | |  |  |  |  |  | |  |  | Icon  Description automatically generated | | Icon  Description automatically generated | Icon  Description automatically generated | Icon  Description automatically generated |  |  | |  |  |  | |  |  |  |  |  | |  |  |  | |  |  |  |  |  | |  |  |  | |  |  |  |  |  | | Turn 2 Scores | | | | | | | | | | A1 1 | | | A2  1 | | A3  1 | | A4  1 | |   Third generation’s genetics: A1: G3\*V2 \*V5 A2: G3\*V4\*V6 A3: G3\*V4\*V7 A4: G3\*V4\*V8  IDs: A1: 9 A2: 10 A3: 11 A4: 12 | |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  | |  |  |  |  |  | |  | Icon  Description automatically generated |  | | Icon  Description automatically generated |  |  | Icon  Description automatically generated |  | |  |  |  | | Icon  Description automatically generated |  |  |  |  | |  |  |  | |  |  |  |  |  | |  |  |  | |  |  |  |  |  | |  |  |  | |  |  |  |  |  | | Turn 3 Scores | | | | | | | | | | A1 1 | | | A2  2 | | A3  1 | | A4  1 | | |

Figure Illustration of the game in the simple example

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Generation | ID | Score | rawScores | ownScore |
| 1 | 3 | 2 | [1,0,2,0] | 2 |
| 2 | 8 | 2 | [0,1,0,2] | 2 |
| 3 | 10 | 2 | [1,2,1,1] | 2 |

Table LOD file of the simple example

|  |  |
| --- | --- |
| Column name | Explanation |
| Generation | Generation number |
| ID | ID of each agent |
| Score | This field based on rewarding scheme value has the following meanings:   |  |  | | --- | --- | | Reward mode | Score Meaning | | 0 | Individual score | | 1 | Mean score of the four agents | | 2 | Max score of the four agents | | 3 | Minimum score of the four agents | |
| rawScores | Scores of all the group members |
| ownScore | The own score of the agent which is selected in the line of decent |

Table Elaboration of the LOD file columns

**Game settings:**

Variable settings:

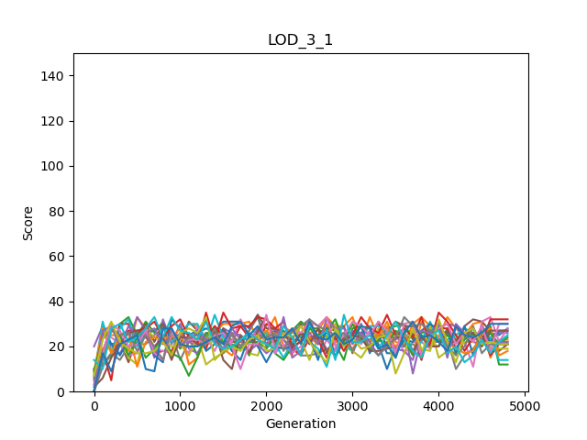
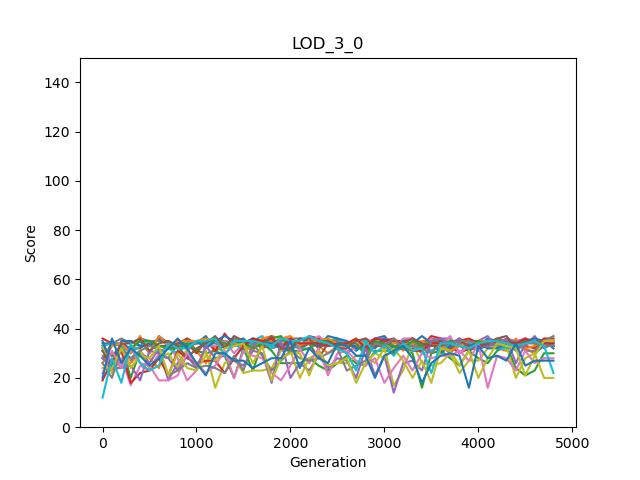
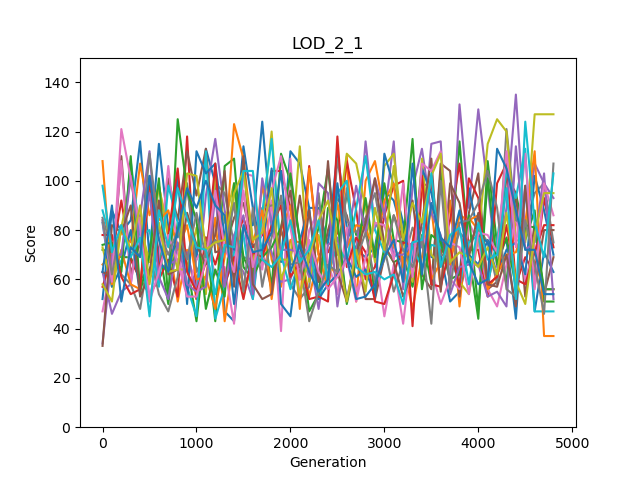
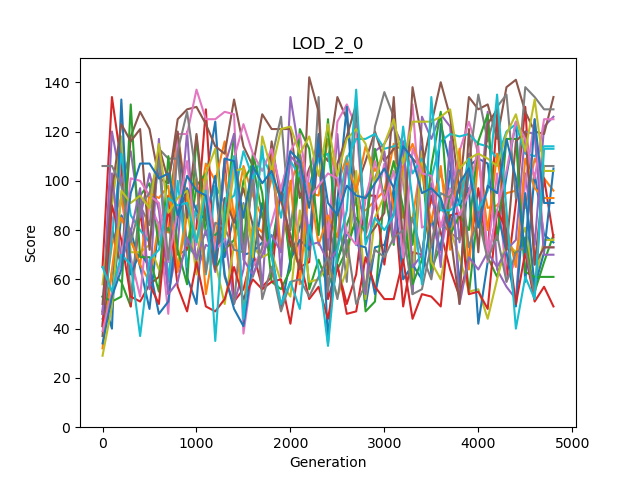
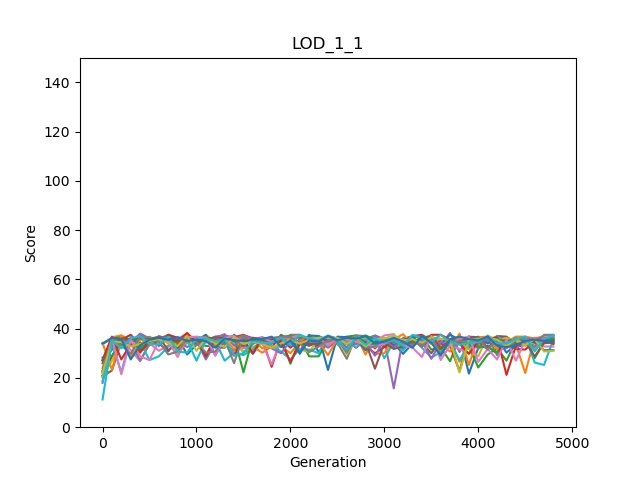
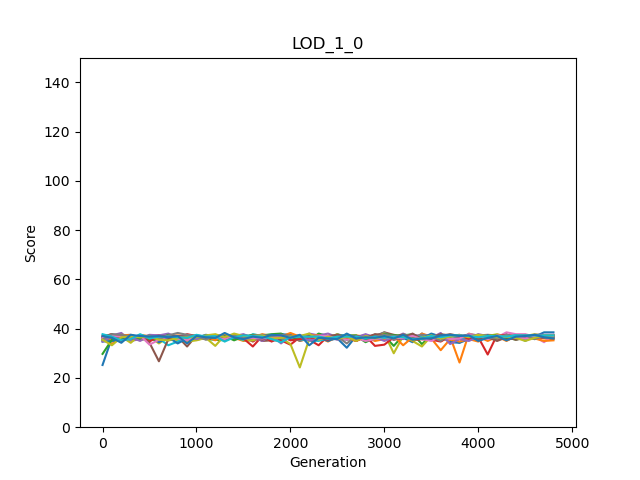
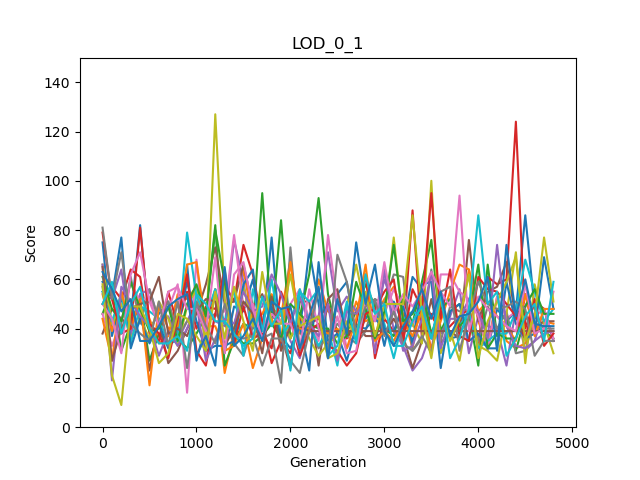
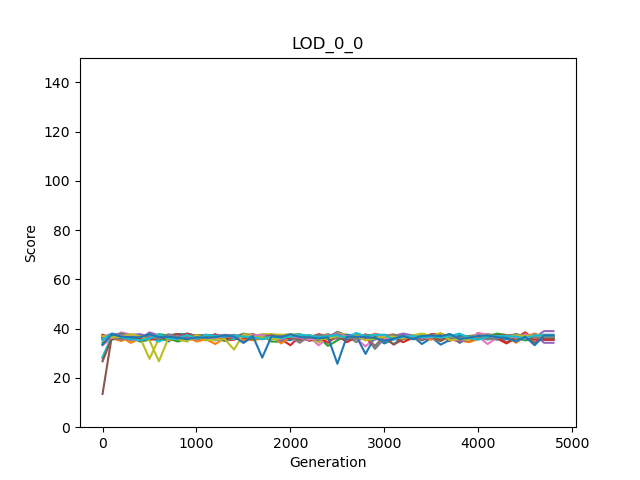
|  |  |
| --- | --- |
| Group mode | Meaning |
| 0 | Clone (automatically get average score for all the four of them) |
| 1 | For different organisms |

Table Different types of group modes

Constant settings:

Other 11 points such as field’s dimension, …

**Results**



Individual | Clone

Individual | Group

Mean | Clone

Mean | Group

Maximum | Clone

Maximum | Group

Minimum | Clone

Minimum | Group

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| rewardGroupModes | Mean  OwnScores | Mean  Minimums | Mean  Maximums | Mean  Averages | Mean  Sums |
| LOD\_0\_0  Group mode: Clone  Reward mode: Individual | 36.40428 | 25.86589 | 47.39261 | 36.40428 | 145.6171 |
| LOD\_0\_1  Group mode: Not Clone  Reward mode: Individual | 45.16521 | 19.59767 | 52.47425 | 36.6448 | 146.5792 |
| LOD\_1\_0  Group mode: Clone  Reward mode: Average | 36.39747 | 26.13605 | 46.98445 | 36.39747 | 145.5899 |
| LOD\_1\_1  Group mode: Not clone  Reward mode: Average | 48.80078 | 10.80952 | 57.2964 | 33.96987 | 135.8795 |
| LOD\_2\_0  Group mode: Clone  Reward mode: Maximum | 87.5481 | 1.79689 | 87.5481 | 30.53644 | 122.1458 |
| LOD\_2\_1  Group mode: Not clone  Reward mode: Maximum | 68.1137 | 1.39553 | 75.93975 | 30.98202 | 123.9281 |
| LOD\_3\_0  Group mode: Clone  Reward mode: Minimum | 31.32459 | 31.32459 | 42.0758 | 36.50899 | 146.036 |
| LOD\_3\_1  Group mode: Not clone  Reward mode: Minimum | 33.70165 | 23.0243 | 44.22643 | 32.88387 | 131.5355 |

# Discussion

# Conclusions

*Text…*

# References