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The Effect of Communication and Cooperation Parameters on Sugarscape

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Abstract. Sugarscape is an artificial society consisting of a cellular landscape of resources (sugar or grain) and a population of agents which need the resources for their survival and search and move to obtain them. When agents reach sugar peaks, the model becomes converges. In this paper, simulation and calculation methods were used. The objective of this article is to study the effect of communication and cooperation parameters on sugarscape. To this end, communication and cooperation parameters were added to sugarscape model and variables such as the average number of agents reached sugar peaks, the average number of living agents and the average collected sugar by agents increased. Thus communication and cooperation lead to improve the sugarscape model.

Keywords: Artificial life, Artificial society, Sugarscape Model, Communication, Cooperation

1. INTRODUCTION

Despite the short history of artificial intelligence, has several concepts have been developed in this regard. Fuzzy logic, expert (knowledge-based) systems, artificial neural networks, evolutionary algorithms, and cellular automata such areas of study in artificial intelligence. Parallel to these areas, a new research field known as artificial life and its sub-fields have come into existence. Artificial life is the study of man-made systems that are designed to behave in a manner that simulate their natural life systems. The artificial life researchers create artificial creatures that live in the real environment, then the behavior of these creatures and how they interact with each other and with their environment aspects are studied. Based on such life, the society named artificial society formed, Artificial society in the computer model includes demographic factors independent of the environment in which the live distinct agents are artificial entities that are in the simulate. Epstein and Axtell example of artificial society created in the name of the sugarscape. Social processes, processes of political and economic processes, including processes that can be modeled in this environment [1-6].

Parameters of communication and cooperation in a model called Vuscape that was similar to the sugarscape model was raised [7, 8]. These parameters were added to the learning environment and lead to improved learning in Boltzmann learning algorithm environment [9,10].Also at issue is the distribution of wealth in society has been used [11,12]. Other applications of these parameters can be reached using the intelligent robots movements [13]. Details of the model citizen and sugar have also been proposed [14]. Now the question is whether adding the two parameters of communication and cooperation to the sugarscape model can improve the model? The purpose of this article, add these parameters to the standard sugarscape that developed by Epstein and Axtell and evaluation of effect these parameters on this environment.

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The organization of this paper is that the sugarscape and its applications were introduced first. In section tree communication and cooperation are described. The implementation described in section four. In section five the two model are compare and discussion and finally the conclusion are given.

2. **SUGARSCAPE**

Sugarscape was first introduced by "Epstein" and "Axtell". The main elements of sugarscape include: agent, rules, environment or landscape, sugar (resource) that are explained in the following [1-6, 15].

a) Agent

The elements present in sugarscape are called agent. Agents include people or organizations that simulate human behavior. The main purpose of agents in the sugarscape is survival. They consume sugar in each period and if they want to survive must always keep sugar levels above zero. Each agent with sugar level below zero automatically dies [1-6, 15].

b) Rules

Rules are for living and survival of the agents in the environment. Different rules induce different behaviors. Execution of rules with different sequences also changes the behavior of agents. There are two main categories of rules in the sugarscape environment include agents' rules and scape's rules [1-6, 15].

c) Environment or Landscape

No certain topology has been defined for sugarscape but we can consider the environment as a two dimensional network [1-6, 15].

c) Sugar

In human societies, people use energy resources for survival. Therefore, in the sugarscape too, the survival equal energy resources defined. Sugar is a source that the agents shall consume for survival and sugar supplies, indicate assets or wealth [1-6, 15].

2.1 Sugarscape applications

One of the applications of sugarscape is wealth distribution in society and the study of how inheritance lead to better wealth distribution, increase population and survival [5, 15]. Also spread of contagious diseases and how get rid of contagious diseases in sugarscape has been analysis [4].Other applications in this environment is evaluate the learning process in this environment [9,10,16].

3. **METHODOLOGY**

To analyze the sugarscape needed simulations and calculations by software programs and the computer models based on artificial intelligence techniques automatically. These programs should be created in such a way and all terms and conditions and specification requirements to comply with the terms of the realities of the real world in which they are defined. In other words, the artificial environment we should be looking for clear definition of the system and determine its specifications.

The method used in this study is based on calculation and simulation. Following the simulation, communication and cooperation in the sugarscape model described.

3.1 Communication and cooperation in sugarscape

Communication can be defined simultaneously or non-simultaneously. By simultaneously communication we mean an agent speaks directly with each one of other agents. But in this manner, the communications of agents become very complex. The other manner is non- simultaneously communications and this type of communication, an agent send a message and an agents or agents receive the message. In this case the communication is regarded as non- simultaneously. If the two agents have the same objective, and if achieving that objective benefits both agents, cooperation seems a plausible act. In the development of our model, we decided to use non-simultaneous communication [7, 10, 17, 18].

The scenario is as follows. An agent meets a sugar mass that exceeds its capacity for cooperation and, therefore, needs the cooperation of another agent. This agent sends a "message" via the main channels for communications through talking to inform other agents of this need. The message is a signal containing the location of the network and the quantity of sugar. Talking starts with a specific priority (probability). The two new rules defined below were added for the purposes of communication and cooperation. Before introducing these two rules, a new parameter, called the Maximum Sugar Harvest (msh) must be defined that was added to the sugarscape. The msh is the maximum number of sugar units that an agent can harvest at each cycle from a cell [7,10,17,18].

a) Talking Rule

If an agent is located at (x,y) in the network and the sugar available in this location is greater than msh, the agent will not be able to harvest sugar. Therefore it broadcasts a message in the form of ((x,y),sugar).

b) Listen Rule

Every agent collects the messages and uses their information in the movement rule (M). If the amount of sugar specified in the message is greater than the indirect neighborhood of the agent, it directly moves to that location (jump) and the specified message is deleted. The agent in that location shares the sugar with the sender of the message (cooperation).

4. IMPLEMENTATION

In this section for evaluation of Effect two parameters communication and cooperation on sugarscape, experiments have been designed as follows.

4.1 The Sugarscape model without communication and cooperation (First Model)

In this experiment, the amounts of sugar, vision level, metabolism, age of the agent and rate of regrowth of sugar in the environment that are the experiment's parameters are shown in Table 1.The environmental rules are local. Agents in the environment move with the rule of agent's movement in a manner that every agent moves to the closest location with maximum amount of sugar in their level of vision (in the neighborhood of the agent) and harvest the sugar present in that location. By the time the agents present in sugar environment reach sugar peaks the model converges. This model has been run for different number of agents as follows: 5, 12, 25, 55, 110, 150, 200, 310, 420, 518, 718, 1020.1500, 2020, 3010, 3200, 3991 and five repetitions for each of them and in each iteration the average number of agents reached sugar peaks at the time of model convergence and the results are shown on diagram 1. Also the average number of live agents and the average quantities of collected sugar by agents after 50 cycles were recorded and the results respectively are shown on diagram 2 and diagram 3.

Table 1. The Values of the selected parameters based on the model number.

Parameter	First model	Second model
Environment		
Dimensions of word	**85*85**	**85*85**
Distribution of initial sugar in environment	**Random**	**Random**
Rate of regrowth environment's sugar	**1**	**1**
Agent		
Amount of initial sugar	**0-1**	**0-1**
Vision level	**1-6**	**1-6**
Metabolism	**0-1**	**0-1**
Age	**60 -100**	**60 -100**
Max sugar harvest	**0-1**	**0-1**
Talk preference	**0**	**1**
Listen preference	**0**	**1**

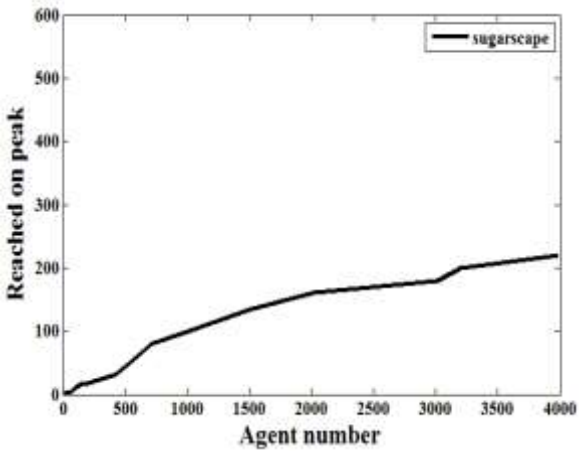

Diagram 1. Average number of agents that reached sugar peaks in the first model.

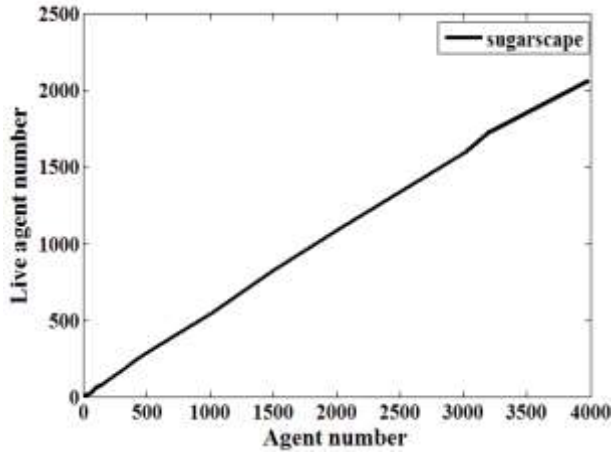

Diagram 2. Average number of live agents in the first model.

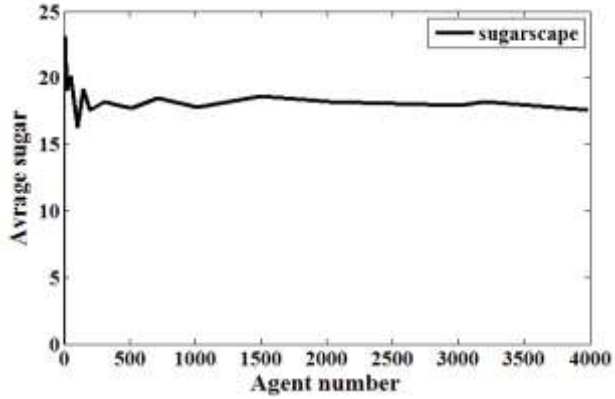

Diagram 3. Average quantities of sugar collected by agents in the first model.

4.2 The Sugarscape model with communication and cooperation (Second Model)

This model is an extended of the sugarscape model. As shown in table 1, the parameters of Maximum Sugar Harvest (MSH), Talk Preference, and Listen Preference were added to the parameters of the previous model, while the other parameters were the same as those in the previous model.

The Movement Rule of this model was also similar to that of the previous model. In this expanded model, communication and cooperation were carried out by following the Talk Preference Rule and Listen Preference Rule for each agent. This model has been run for different number of agents as follows: 5, 12, 25, 55, 110, 150, 200, 310, 420, 518, 718, 1020, 1500, 2020, 3010, 3200, 3991 and five repetitions for each of them and in each iteration the average number of agents reached sugar peaks at the time of model convergence and the results are shown on diagram 4. Also the average number of live agents and the average quantities of collected sugar by agents after 50 cycles were recorded and the results respectively are shown on diagram 5 and diagram 6.

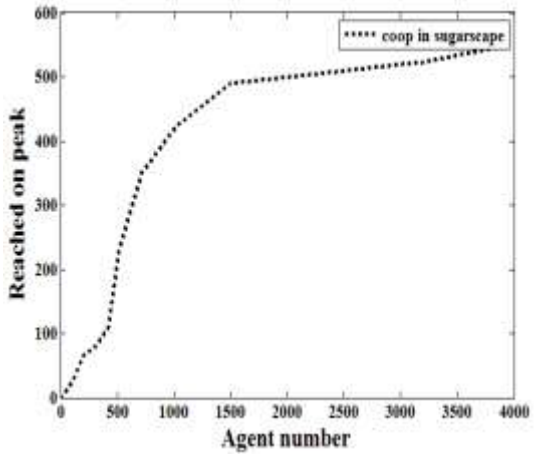

Diagram 4. Average number of agents that reached sugar peaks in the second model.

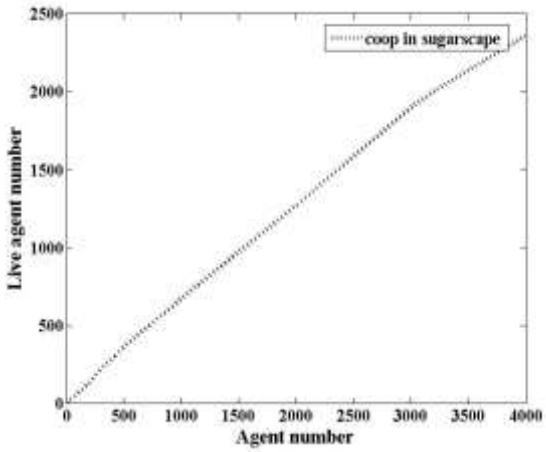

Diagram 5. Average number of live agents in the second model.

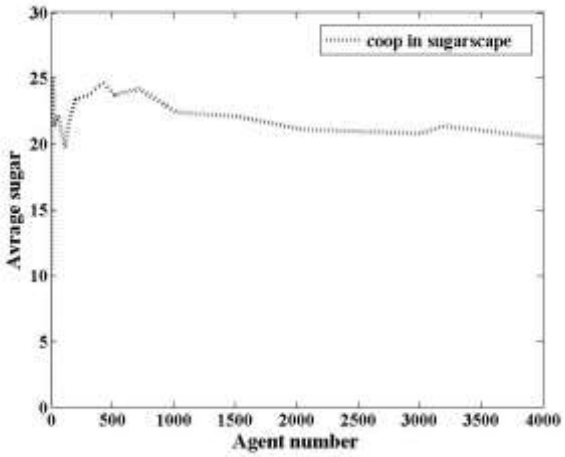

Diagram 6. Average quantities of sugar collected by agents in the second model.

5. COMPARISON AND DISCUSSION

Comparison diagram 1 and diagram 4 in diagram 7 have shown. The evaluation of diagram 7 and table 2 shows that increasing the number of agents that reached sugar peaks after adding two parameters the communication and collaboration to the sugarscape model. In relation to number of live agents, the comparison diagram 2 and diagram 5 have shown in diagram 8. The evaluation of this diagram and table 3 shown that increasing the number of live agent after adding two parameters the communication and cooperation to the sugarscape model. In relation to the average quantities of collected sugar, the comparison diagram 3 and diagram 6 shown in diagram 9. The evaluation of this diagram and table 4 shows that increasing the average quantities of collected sugar by agents after adding two parameters the communication and cooperation to the sugarscape model.

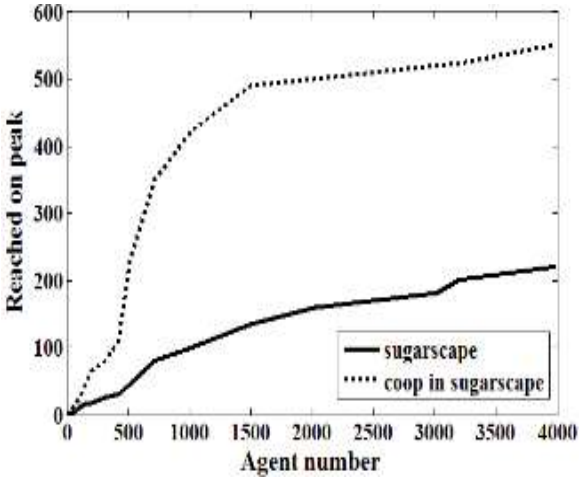

Diagram 7. Comparison between the average numbers of agents that reached sugar peaks in the first and second model.

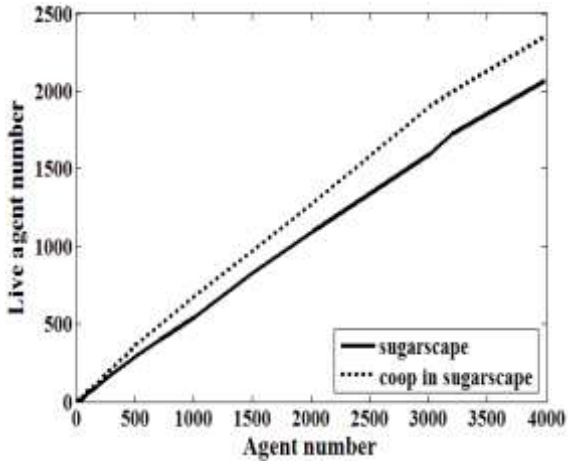

Diagram 8. Comparison between the average numbers of live agents in the first and second model.

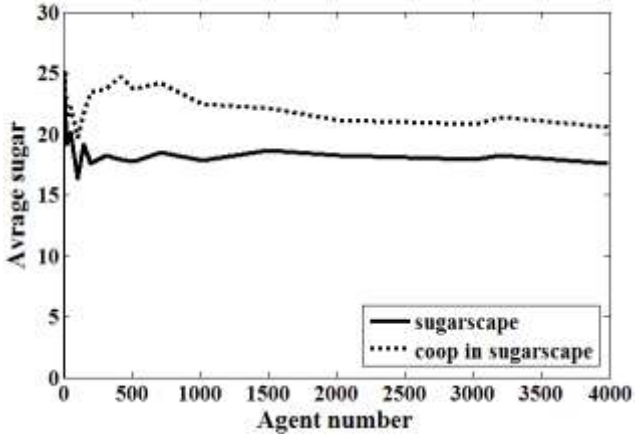

Diagram 9. Comparison between the quantities of sugar collected by agents in the first and second model.

Table 2. Distribution of average number of agents that reached sugar peaks based on the model number

Number of agents	**First model**	**Second model**
5	1.1	1.1
12	1.2	1.3
25	2.5	4.1
55	3.2	10.1
110	10.2	25.5
150	15.3	43.4
200	17.5	65.2
310	25.1	80.6
420	30.6	109.5
518	45.7	230.2
718	80.3	350.4
1020	100.1	422.3
1500	134.2	490.2
2020	160.2	500.3
3010	180.3	520.4
3200	200.4	523.2
3991	220.2	550.7
Average	**72.2**	**231.1**

Table 3. Distribution of average number of live agents based on the model number

Number of agents	**First model**	**Second model**
5	2.1	2.1
12	5.1	5.1
25	12.4	17.6
55	20.3	26.2
110	60.2	70.1
150	80.1	98.4
200	109.2	131.2
310	177.2	224.3
420	242.2	298.6
518	296.3	372.2
718	395.5	492.4
1020	550.6	681.3
1500	825.9	970.5
2020	1099.4	1283.6
3010	1596.3	1904.5
3200	1728.4	2002.2
3991	2069.5	2353.4
Average	**545.3**	**644.2**

Table 4. Distribution of average quantity of sugar collected by agents based on the model number

Number of agents	**First model**	**Second model**
5	20.6	20.6
12	23.1	25.1
25	19.1	21.3
55	20.1	22.2
110	16.3	19.7
150	19.1	21.7
200	17.6	23.4
310	18.2	23.7
420	17.9	24.7
518	17.7	23.7
718	18.5	24.7
1020	17.8	23.7
1500	18.6	24.2
2020	18.2	22.1
3010	17.9	21.1
3200	18.2	21.04
3991	17.6	20.5
Average	**18.6**	**22.2**

6. **CONCLUSION**

In this paper the sugarscape model without the communication and cooperation parameters was considered and the variables average number of agents reached sugar peaks at the time of model convergence and the average number of live agents and the average quantities of collected sugar by agents were calculated. After adding these two parameters to the mentioned model, the mentioned variables were calculated again. The results show after adding this two parameters the mentioned variables increased and sugarscape model was improved. Also the result show that however all named variables were improved, convergence time was increased due to the increased processing in each run when communication and cooperation added to the model. Therefore adding communication and cooperation lead to improve the sugarscape model. In future studies the impact of communication and cooperation on the sugarscape model based on brain emotional learning will be examined.

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