Using of computer simulation and computer analysis as a new way to resolve problems

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ABSTRACT
Recently, computer simulations and its applications have been estimated in the field of research of cognitive sciences, sociology, economics and other humanities. In this article author pay attention into revising the significance of attainment experiences and transaction by artificial negotiators in expansion of some economic and welfare standard in an artificial society model simulated by computer .Using Netlogo software, notions, rubrics and structures of planned model; has been simulated. Then by changing the parameters and policy in plentiful experiments, properties of those rules and factors in considered criteria was considered.
The conclusion and results of experiments displayed that when agents act with trial and error to utilize the environmental possessions (opportunities), the agents' death proportion were augment wealth distribution inequity arises among agents and the average wealth of agent's decreases. Also the results had shown that just the experiences attainment does not initiate notable improvement in deaths ratio and fortune distribution norm. On the other hand, that attainment with experiences exchange among agents makes remarkable deaths downturn, wealth expansion and wealth distribution equity. Thus the exchange of experiences in a human society can involve welfare expansion, evenhandedness and fairness.

Key-words:
simulation- wealth-artificial- agents- society

1. Introduction

A key phase in understanding complex systems depends on the Knowledge of how those systems are. The complication of a system is directly related to the amount of the requisite knowledge for describing it [1]. According to this scheme, scientists can understand the complexity of social systems and human societies. Apparently, such complex social systems in combination with the behavioral system of humans may put out complex processes which cannot be understood and considered through traditional methods [24]. Also modern social processes are so multifaceted that they cannot be easily divided into independent and simple sub-processes. Such reasons make the study of human societies a tricky challenge [3]. currently, by extending realm of new sciences, techniques and technologies and utilizing these amenities to realize the ideology that are governing the world, also the humanities researchers going to use computer simulations and other computational methods in the way of better understanding the rules and scientific phenomenon in humanities. In social simulations, researchers apply computational methods, predominantly computer simulations to generate artificial societies which encompass agents, environments, features and rules which conform to real world features and rules. Then the rules and features related to the considered phenomena will be applied to artificial society and the evolving changes will be traced to consider the principle governing the world. In the same manner the result of various phenomena's which may take place in future can be revising. Also a variety of situations which may waste further money and time to produce them can be considered and subsequently it is tried to optimize them.

1.1 Recent Methods

First beams of social simulations emerged with introduction of agent-based models in 40s. The pioneer of this field was John Von Neumann (1903-1957) who proposed the idea of a machine capable of reproducing itself. In fact he combined the basic features of life (e.g. reproduction) and machine capabilities. In the same time, Stanislaw Ulam and Neumann who were cooperators in Los Alamos National Laboratory introduced the concept of cellular automata which may be considered as basic idea of artificial life. Subsequently in the 50s the cellular automata concept was applied as a model for describing biological systems [4].

In October of 1970, John Horton Conway a British mathematician proposed a mathematical game; that was the game of life which has attracted the attention of many researchers. The game was a simplified form of Neumann's cellular automata and used simple rules to illustrate the manner in which artificial agents live in a two dimensional cellular automata [8]. In 1971 Thomas C. Shcelling proposed the segregation models by using two-dimensional cellular automata. He showed that agent individual preferences in a society to have neighbors of their own kind may lead to large-scale social segregation patterns. Despite many efforts made by researchers to

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extend the social simulations since 40s, they achieved no impressive success because such extensions strictly necessitated using complex computational procedures, whereas there was lack of sufficient computational facilities until 90s [9].

In 1996 Joshua M. Epstein and Robert Axtell proposed the Sugar scape Model on their book [3]. Since then, this model has been applied to describe various social and humanity concepts such as seasonal migration patterns, disease outbreak modality in societies, explanation of reproduction, etc.

2. Basic concepts and theoretical principles

2.1 Artificial Life and Evolution

The word "Artificial" in the phrase "Artificial Life" implies this fact that at last whatever is produced that is made by human and is not provided by nature during evolution [24]. The artificial life consists of biological components (living artificial organisms) that are created by synthetic methods such as software- simulated - methods, hardware methods or biological and robotic methods and these components are controlled in an artificial environment. The real world organisms have some characteristics like hemostas is, reproduction, storing and consuming energy, growth, response to stimuli and adaptation [5]. Similarly artificial living organisms should have all or some of these features depending on the goals they have been created for. For example artificial organisms are capable of responding to stimulants so that the set of their reactions include the behavior of those organisms. Also artificial organisms may have homeostasis characteristic which due to it, regulate their internal status to reach a stable state. This stable state can be considered as a general goal by artificial organisms, so that each generation of the same organism also regulates their activities and evolutionary movement toward that goal.

2.2 Artificial Society and Social Simulations

An artificial society is composed of a set of artificial living elements or agents which lives in an artificial environment. Also, there are agent-to-agent and agents-to-environment interactions into the society according to some special rules. Some people believe that social simulations beside inductive and deductive methods form third-research style in social sciences and it can be used to generate data which they may be compared and analyzed by researchers to understand social structures and group behaviors [23].

2.3 Sugarscape Model

The Sugarscape model consists of agents, environment and rules that form agent-to-agent and agent-to-environment interactions. In this model the environment is composed of a 2D-cellular automaton in which each cell has specified amount of resources denotes as "sugar". Agents move rotational and obtain sugar from the environment. Agents have a vision scope according to it, they can look around, find cells and having sugar, move toward them and harvest included sugar. After consuming the content of a cell, their sugar amounts intensify to achieve a specified maximum. In each time interval, sum of the obtained sugar from environment will be spent to supply agent's metabolism and surplus is saved as agent's wealth or assets. In such environments, the agents may affect each other or environment. For example the agents may reproduce, leave pollution or inherit their assets to their children. So some social phenomena can be studied by measuring average amount of sugar obtained by agents, agents' mortality factor and other specified measures.

3. Methodology

In this paper attempts have been done to apply simulation tools to create an artificial society in which the agents acquire experiences during working in the environment and exchanging the experience among themselves. It is also attempts to investigate how deployment and exchange of experiences among agents affect social welfare.

3.1 Determination of Criteria and Research Methods

By determining some welfare criteria in the artificial society, the effect of some phenomena on these criteria such as experience acquisition and sharing can be investigated. In this case, the following criteria are introduced and taken into account as reference criteria:

3.1.1 Gini Index and Lorenz Curve

Gini index is one of the statistical indicators which are used to illustrate equity of wealth (or income) in a society. Gini index always have a value between 0 and 1. For values closer to 0, stronger wealth inequity will gain, and on the other hand closer to 1, more equal wealth distribution. This indicator provides summarized data and facilitates comparing of various results of experiments.

It is notable to say that the Lorenz curves are used in analysis of various experiments. The Lorenz curve can be used to show the proportion of population and wealth amount owned by that population. In Lorenz curve, the identity function line can be considered as a reference to illustrate equity in wealth distribution. So more similar the

Lorenz curve to the reference line, more equal wealth distribution is seen.

3.1.2 Agents' Average Wealth

This indicator implies the average amount of wealth that agents obtain during their lives. According to it, the success of agents to exploit resources of environment can be measured.

3.1.3 Starvation deaths ratio

One reason that makes an agent die is the lack of sufficient sugar for supplying the agent's metabolism. So the mortality of agents depends on the economic status of the agents. By using this indicator the social welfare status of agents can be study. In fact the death from starvation indicator shows the number of agents that die from the lack of sufficient sugar during an experiment.

After determination of measures and criteria, the artificial society will be simulate, so the agents act randomly and by using trial and error in harvesting sugar from environment resources. Afterward the society is simulated so that agents acquire experiences during their activities in the environment, use their experiences if necessary and exchange experiences among themselves. Then the results will be recorded and measured and finally the outcomes of simulations will be compared.

According to this, a model is chosen from the Netlogo library model which is designed according to the wealth distribution model presented by Epstein and Axtell and implemented by Uri Wilensky based on sugarscape model [7]. Then by extending this model, and applying desirable conditions, the necessary parameters, rules and measures are formed.

3.2 Characteristics of the developed artificial society

According to the above discussions artificial society is created based on the sugarscape model. As described earlier, the model consists of agents, environment and rules that define the agents' life framework in the environment. The features of the society are described as follow:

- Environment Features
    - The environment is composed of a cellular automaton with 50×50 cells.
    - Sugar is distributed among the cells randomly. The maximum amount of sugar that a cell can contain (maximum sugar capacity of cell) is determined at the start of the simulation for each cell randomly.
    - Each cell has a dedicated key that is randomly chosen from a key space and will be assigned to each cell at the start of simulation. Expanse of key space depends on the environment complexity. The environment complexity is an integer adjustable from 1 to 100. For example if the environment complexity is adjusted as 35, the cells key will be random integer betweens 1 to 35. Similarly the probability of finding the key by agents is one-thirty five ($\frac{1}{35}$).
- Agents features
    - Each agent has an ID as well as color, shape and size.
    - Each agent is zero years old at birth. Also the maximum age of the agent is determined randomly and assigned to that agent at birth.
    - Some random amount of sugar is endowed to each agent at birth in order to be able to start its activities in the environment. Afterward the agent can increase its wealth by exploitation of environment resources.
    - The metabolism rate of an agent is determined and assigned to the agent at birth and won't be changed until the end of simulation. Metabolism implies the amount of sugar that an agent needs in each time unit in order to keep on its activities.
    - The vision parameter of an agent is determined randomly at birth. The vision parameter determines the number of cells that all agents can see from where he is currently standing. The vision parameter of agent is changeless during the simulation.
    - Each agent has a set of experiences. Each experience consists of coordination of a cell in the environment and corresponding key of that cell. Each agent at birth has an empty set of experience.
- Rules
    - If the agent's wealth (sugar) is equal to or less than zero, the agent will die.
    - The age of the agents increase one unit in every time step.
    - If the age of an agent exceeds its specified maximum age, then the agent will die and disappear from the environment.
    - Each agent should know the cells, key to be able to harvest the cell's sugar capacity.
    - If an agent dies, another agent will be born in a random place in the environment.
    - At the start of simulation, all the agents will disperse on the environment in a uniform random manner.

- Due to the vision parameter, the agents move toward nearest cell that contains most sugar amount.
- If the agent knows the key of a cell, it can harvest whole content of that cell.
- The sugar amounts of cells reproduce continuously with a constant rate. This reproduction stops once the content exceeds the intended maximum capacity.
- If the learning and experience capabilities are involved in the simulation, agents share their attained experiences with each other in specified time intervals. So the agents exchange experiences among each other, (better to say that they train each other).

4. Simulations and Experiments

In this section various experiments have been accomplished by artificial society's studying. And by comparing the outcomes, an attempt has been done to study the effects of experience attainment (learning) and exchange (training)by agents on the wealth distribution and society welfare.

Some of the environmental and agent-related parameters are illustrated in table1 and table 2 respectively. The parameters that vary in various simulations will be mentioned in their own place.

Table 1: Environmental parameters

Environmental Complexity	Maximum Sugar Capacity Of Each Cell	Cells key
35%	50 sugar unit	1-35 Random

Table 2: Agents-Related Parameters

Vision Scope	Agents Maximum Age	Agents Metabolism rate	Agents Maximum Sugar Endowment	Agents Minimum Sugar Endowment	Initial Population
1-6 random	60-100 random	1-4 random	25 sugar unit	5 sugar unit	250 agents

4.1 Experiment 1 – Society without experience attainment and exchange

In this experiment the artificial society is simulated; so the agents won't achieve experience. Obviously in such circumstances, exchanging the experience is meaningless. So in present study all the agents act with trial and error and no experience is used. The experiment has continued for 2500 time units and finally the results have been recorded as in table 3.

Table 3: value of measures at the end of experiment 1

Starvation Deaths Rate	Gini Index		Agents wealth Average	
35466 agents	At the beginning of simulation	At the end of simulation	At the beginning of simulation	At the end of simulation
	0.547	0.525	30 sugar units	36 sugar units

As it can be seen in table 3, the agents' wealth average has been increased by 20% and Gini index has improved by 4% comparing to the beginning of the simulation. It is worth mentioning during the experiment the agents' wealth average diagram has some fluctuations indicating instable economic situation during the experiment (Figure 1). Also the Gini index diagram and Lorenz curve which are shown in figure 1 and 2 illustrates wealth distribution and indicate inequity in wealth distribution, respectively.

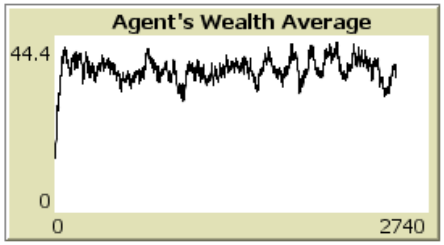

Fig. 1 fluctuating diagram of agents wealth average during experiment 1

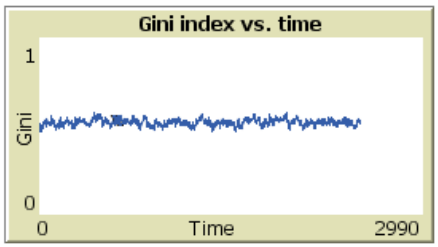

Fig. 2 Gini index diagram in experiment 1

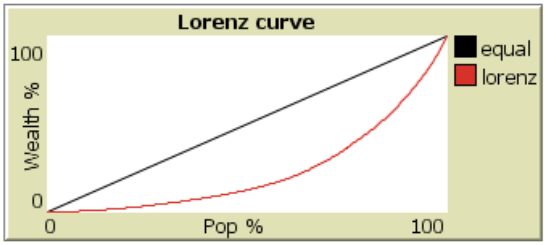

Fig. 3 Lorenz curve that related to wealth distribution in experiment 1

4.2 Experiment 2 – Society with experience acquirement, but without experience interchange.

This experiment is arranged in such a way that agents can gain experience but cannot exchange attained once. The basic question in this research is how downright experience acquirements by agents affect the specified measures of the society. The experiment has lasted about 2500 time units and finally the measures have been recorded as in table 4.

Table 4: value of measures at the end of experiment 2

Starvation deaths rate	**Gini Index**		**Agents wealth average**	
35018 agents	At the beginning of simulation	At the end of simulation	At the beginning of simulation	At the end of simulation
	0.549	0.528	29 sugar units	38 sugar units

The results suggest that learning capability and individual experience gains by agents makes 3.8% improvement in Gini index and 31% growth in average wealth of agents. In this experience also some fluctuations can be seen in wealth average diagram which is shown in figure 4. Considering the Gini index and Lorenz curve diagram, you can see the inequity in wealth distribution in the society (figures 5 and 6).

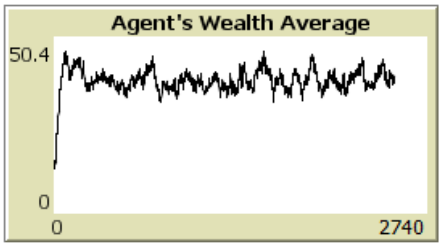

Fig. 4 Fluctuation Diagram of Agents Wealth Average during Experiment 2

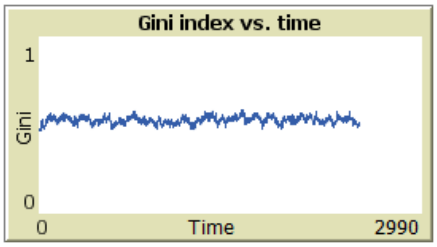

Fig. 5 Gini Index Diagram in Experiment 2

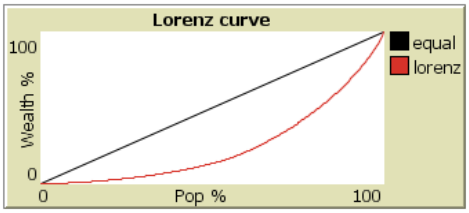

Fig. 6 Lorenz Curve Related to Wealth Distribution in Experiment 1

4.3 Experiment 3 – The Society with Experience acquirement and interchange

In this section the society is simulated in such a way that agents can attain and exchange experience. The experience exchange process is designed, there for in each

time unit, all adjacent agents share their gained experience with their neighbors. In fact, following that process the adjacent agents synchronize their experience. The experiment results are recorded and illustrated in table 5.

Table 5: Value of Measures at the End of Experiment 3

Starvation Deaths Rate	**Gini Index**		**Agents Wealth Average**	
1963 agents	At the beginning of simulation	At the end of simulation	At the beginning of simulation	At the end of simulation
	0.546	0.381	30 sugar units	238 sugar units

The result of this experiment shows impressive decrease in starvation deaths rate and influence intensification in agents' wealth average comparing to the previous experiments in which no experience interchange was occurred. Also an improvement has occurred in Gini index by 30.2% comparing the beginning of this experiment. On the other hand, a growth has occurred in agents' wealth average by 693.3% comparing to the beginning of experiment. Results of these experiments where shown in figure 7 up to 10.

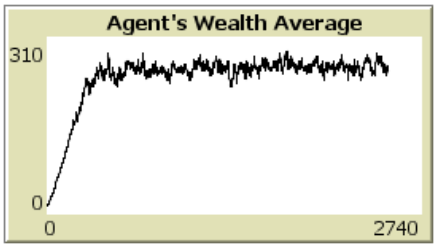

Fig. 7 fluctuation diagram of agents wealth average during experiment 3

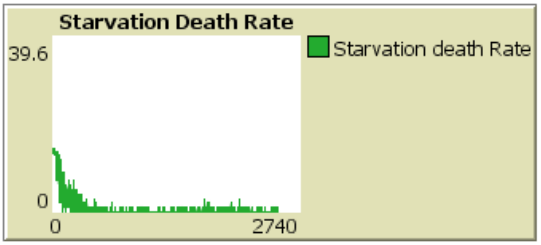

Fig. 8 Starvation deaths rate during experiment 3

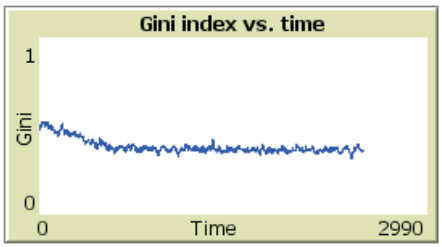

Fig. 9 Gini index diagram in experiment 3

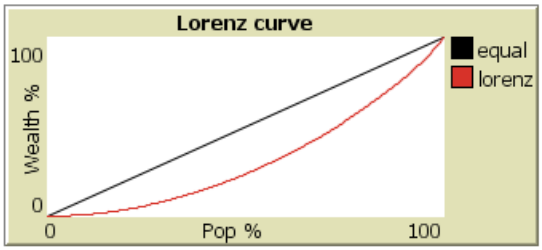

Fig. 10 Lorenz curve related to wealth distribution in experiment 3

Fast growth of agents' wealth average can be seen in figure 7 since the beginning of the experiment. By intensifying this average up to 240 sugar unit, it continues with low fluctuations. Low fluctuations in this diagram imply relatively stable economic situation in this experiment. As it can be seen in figure 8 the starvation deaths rate is reduced during the experiment compare to the beginning of the experiment. Also decrease in Gini index shown in figure 9 and verge of Lorenz curve to reference line shown in figure 10 imply more equity in wealth distribution in experiment 3.

In experiments such as experiment 3, it is obvious that once the learning capability is disabled, the adverse effects are seen in economic measures of the society.

5. DISCUSSION:

Numbers of research have been carried out by some Iranian researchers (Arash Rahman, Saeed Setayeshi and Mojtaba Shamsaee Zafarghandi) in various domains such as health administration[16,17,25], social welfare [24], wealth distribution and adjustment [12,13,15,21], evolution [26] and application of artificial societies in analyzing and optimization of complex systems [14,18,20,22]. Of course most of these researches are based on the Sugarscape Model. The organization of this article is as follows. Basic concepts and theoretical principles are described in section two and the methodology used in this article is introduced in section three. In section four, the artificial society with various circumstances is simulated and corresponding results of experiments are recorded and measured. In section five the

comparison and analysis of outcomes and finally the conclusion are presented.

In this section authors analyze the effect of experiment attainment and exchange, in a society by comparing the achieved findings. In table 6, the corresponding results to each of the obtained measures of above experiment were shown.

Table6: The Values of Each Measure in Artificial society Corresponding to Various Circumstances in Experiments

experiment	Experience attainment	Experience exchange	Gini Index at the End of Experiment	Starvation Deaths of Agents	Agents Wealth Average at the End of Experiment
1	No	No	0.525	35466	36
2	Yes	No	0.528	35018	38
3	Yes	Yes	0.381	1963	238

Also in table 7, the improvement quantity in measures caused by the agents' behaviors are shown.

Table 7: The Effect of Using different circumstances On The improvement of Society's Criteria

Wealth Average Improvement	Gini Index Improvement	Experience Exchange	Experience Attainment	Experiment
20%	4%	No	No	1
31%	3.8%	No	Yes	2
693.3%	30.2%	Yes	Yes	3

The improvements in measures are determined by comparing the change ratio in beginning and end of each experiment. For example in experiment 3, Gini Index has changed from 0.546 at the beginning to 0.381 at the end. So regarding to the fact that degradation in Gini index is desirable in the society, the amount of improvement of Gini Index in experiment 3 can be considered as 30.2%. Other improvements are determined in a way as described above.

Figure 11 illustrates a comparing representation of agent wealth average in various experiments. In this figure, the red, blue and black lines are related to the experiment 1, 2 and 3 respectively. As can be seen in figure 11, agent wealth average in experiment 3 is higher than experiment 1 and 2.

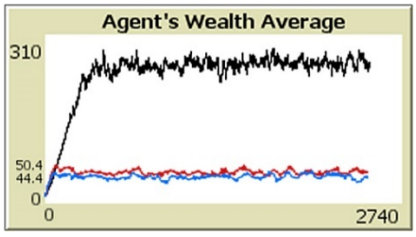

Fig. 11 Comparing the Related Diagram Agent wealth Average in Experiments

Figure 12 shows Gini index status in three experiments. In this figure blue line is related to experiment 1, yellow diagram is related to the experiment 2 and the red diagram is related to the experiment 3.

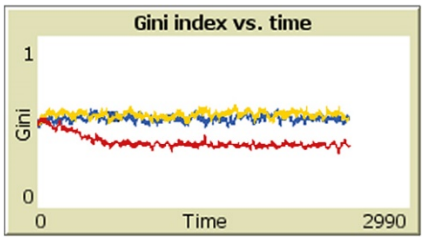

Fig. 12 Comparing Diagram of Gini Index in Three Experiments

As it can be seen in figure 12, an impressive intensification has been occurred in experiment 3 in which experience exchange has involved comparing the other two experiments.

According to the above tables and figures, this fact can be seen that, if any of the agents operate in environment with trial and error, so there will be no impressive improvement in society's economic measures; also if agents only attain experience and didn't exchange experiences, there will be a little improvement in social measure. On the other hand, if agents attain any experience during operating in the environment and exchanging attained experience to other agents it enhances the wealth increase, the equity in wealth distribution and degradation in agents' starvation deaths rate and subsequently it causes more improvement in social welfare.

6. Conclusion

In this paper the effects of experience attainment and exchanging were studied through simulated an artificial society. The results shown that, the agents' attempts with trial and error to use environmental resources make no impressive improvements in social welfare. The results show that the experience exchange is necessary to improve the social welfare measures as well as the experiments attainment. So it can be concluded that knowledge attainment and distribution among agents can provide more opportunities for them to gain access to environmental resources and consequently the improvement of their social welfare.

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