

Zamin, An Agent Based Artificial Life Model

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Abstract. Zamin artificial life model is designed to be a general purpose environment for researches on evolution of learning methods, living strategies and complex behaviors and is used in several studies thus far. As a main target for Zamin's design has been its expandability and ease of problem definition, a new agent based structure for this artificial world is introduced in this paper, which is believed to be much easier to use and extend. In this new model, all control and world running processes are done by agents. Therefore, any change in world processes does not require recoding the main engine and can be done just by altering the behavior of one or some agents. To have an easier interface for the design of new organisms, all creatures' communications with the world level is done through a common message map, thus, a designer just needs to code the required parts and append them to the main system to process the necessary messages. And at last, extending the model can be done with much less effort, as it can be done easily by creating new agents that handle the new tasks. This model is implemented and some coding differences with previous model are presented.

Keywords: Artificial Life, Modeling, Agent Based Systems

1 Introduction

Computer and mathematical simulations of real life can help in two important matters: First, to evaluate assumptions about real life by implementing them with a strict language and second, to explore the interactions between different contributing factors influencing the behavior of the creatures (Barret et. al., 2002). The first artificial life model was introduced in 1966 by Von-Neumann (Von Neumann, 1966) as the idea of creating cyber-organism, capable of showing characteristics of living creatures such as reproduction, self-healing, growth, etc. Von Neumann's first artificial life environment was a simple cellular automaton which evolved patterns that could influence on their surrounding cells and change them so that they would resemble the same pattern. Artificial life continued in several different forms and with several different targets in the next years such as studying the evolution of complex behaviors (Langton, 1992), (Hraber et. al.,

1997) and (Halavati and Shouraki, 2003), emergence of social behaviors (Mascaro et. al., 2001), simulation of natural creatures (Merks, et. al., 2003), emergence of computer programs (Ray, 1992), etc.

There is no general artificial life model for cognitive studies on evolutionary behavior and several models are created each year to host specific experiments. ZAMIN¹ artificial life model is designed for cognitive studies on evolution of complex behavior, decision making methods, & living strategies. The main design targets for this model have been to construct a system which can simulate different types of living strategies, climates, controlling, and communication systems while being easy to understand and expand. Although Zamin has been used in many several researches till now and proved to be a suitable modal for different experiments (e.g. see (Halavati and Shouraki, 2003), (Zadeh, et. al., 2003), (Halavati et. al., 2004), (Zadeh et. al., 2004)), a restructure of Zamin is presented in this paper, which is believed to make it easier to use, change and expand. The new model is totally agent based and all tasks are performed by re-programmable agents. Hence, there is no need to change the main engine to alter a specific world control mechanism or change an organism's structure.

The rest of this paper is organized as follows: Next to this part, there is a section on Zamin model describing its general and external view. The third section describes its underlying structures and creatures models. Then a brief section on the comparison between coding in this model and the previous one is presented. And the last part is the conclusion and future works.

2 Zamin Artificial Life Model

Zamin environment is a lattice that can nest several different inhabitants. The inhabitants are grouped into three major groups: simple organisms, animals and agents. Simple organisms are creatures that can get materials from the world and reproduce once they have sufficient resources, but they can not move, communicate or respond to stimuli. Animals can move through the world and choose their actions on their own will. They can manipulate simple organisms and objects,

¹ Zamin means 'Earth' in Persian.

trade information or energy with each other, attack others, etc, but they can only access the world using a limited passage, both to see the world and to choose actions. The third class belongs to agents. Based on their duties, agents have different access levels to the world and they may manipulate all parts of it, without limitations and therefore, they can control the world flows and cycles.

Animals can be designed to reproduce sexually or asexually. They are all assumed to be egg-laying, but the requirements for eggs hatchings are programmable and one can set the eggs to hatch immediately and thus have live-births. In sexual reproduction, rape and consensual mating are possible for both sexes and required mechanisms for different mate choice approaches are predefined. Once a female animal mates or an asexual animal decides to start reproduction, she gets pregnant and during her pregnancy period, she can transfer resources to the embryo or embryos which are supposed to be put in eggs.

Animals can communicate through two methods: they can broadcast a message (a sequence of characters) in a selectable range or to transfer it directly to another animal. All controls on the limitations of such a transfer are left to the user.

At each time step, each living creature needs to have a minimum level of energy to stay alive and act. This energy can be derived from the resources that the creature absorbs. The world has a closed material and energy cycle with definable number and types of materials and chemical reactions to transfer materials and energy to each other. Only simple organisms can absorb materials directly from the world level and animals must eat simple organisms or other animals' flesh or eggs to receive resources. Each creature may be able to use some of the existing chemical rules to convert its absorbed resources into energy. After organisms release energies as the result of actions or release materials as waste, they released items return to the world to flow again in world's material and energy cycle.

The time is quantized and each non-agent organism can choose at most one action at a time step. But different organisms can have different reaction speeds based on the frequency of their action choices in a sequence of time steps.

3 Zamin's Underlying Structure

Zamin's main world is a simple lattice, where a number of creatures can live in each cell of it. The only thing that the world provides is a place to hold creatures' positions and their message maps. Six agents are in charge of running the world. These six agents are in charge of creation and destruction of creatures, flowing the time, managing the positions and resources, giving information to limited creatures (non-agents), and applying creatures' wills. A user of Zamin world does not need to deal with these agents to design new

creatures and they must be modified only to make a major change in Zamin's governing behavior. To design a new organism, the appropriate abstract class must be selected and implemented so that new creature will be able to respond appropriately to the messages it receives.

3.1 The Six Main Agents of Zamin

3.1.1 The Lives Lord, Espand²

Lives' lord, who is called Espand, is in charge of creation of agents, animals and simple organisms. All new types of creatures in Zamin must be registered with Espand and every time that a new creature is required, Espand creates it. She is also in charge of population control for all creatures to put an upper (and if required lower) limit on their populations.

3.1.2 The Times' Lord, Zorwaan

The times' lord or Zorwaan is in charge of turning the time's wheel in Zamin. He does that by sending aging and action selection messages to all creatures. At each time step, Zorwaan increases each living creature's age and sends him/her a message, to let him/her choose an action to perform.

3.1.3 The Positions Lord, Hormoz

Hormoz is in charge of objects and creatures transfers in the world. When something must be moved in Zamin, Hormoz does that. He creates the world map and all limitations on movements and transfers are applied by him.

3.1.4 The Resources' Lord, Kiumars

Kiumars manages resources and energy transfer and transforms in Zamin. He is also in charge of getting the living costs from all living creatures and giving resources to simple organisms. A finite number of elements and several rules that describe the transformations of these elements in to energy and from energy may be defined in Zamin's configuration file. For example, one can specify that the world starts with 10000 units of element A and 5000 units of elements B and C, where one unit of element A and two units of element B produce three units of energy and one unit of waste element C. Each creature must absorb elements and apply a subset of defined transformation rules to produce energy. At each time step, Kiumars takes a certain amount of energy from each creature and those who do not afford it are introduced to the lives' lord to be killed.

3.1.5 The Gates' Lord, Ashtaad

No animal can access the world directly and unlimited. Thus, Ashtaad, the lord of the gates, is in charge of controlling animals' access to the world level. Once an

² Espand, Zorwan, Hormoz, Kiumars, Ashtaad, & Mitra are some of Persian mythological deities, related respectively to sacredness of the life, time, creation of universe, the mines, truth, and oaths.

animal is given a chance to choose action or learn something from the world, Ashtaad is its medium to get data from the world and she puts the necessary limits on the data requests.

3.1.6 The Actions Lord, Mitra

Mitra is the last of the six main agents. She is in charge of accepting animals' and simple organisms' requests and applying their wills in the world. Once an animal wishes to perform an action, s/he passes the request and all the details to Mitra and if she accepts the request as applicable, manages to perform the will.

3.2 Simple Organisms' General Structure

Simple-organisms class can be used to design creatures which are almost as complex as plants. At each time step, a simple organism can request for some resources from the world, exploit some of the absorbed resources to get the energy necessary for living, or produce seeds and create another organism of its own type. Simple organism properties can be seen in Table 1. To implement a creature at this level, one must implement functions that respond to creation and action selection messages. Their action choices are to get resources and to produce seeds.

3.3 Animals General Structure

Animals have some extended properties and many more action choices over simple organisms and must respond to more messages. The complete list of these properties, action choices, and messages are presented in Tables 2, 3, and 4. To implement an animal, almost all specified messages must be implemented so that the creature would be able to choose his/her actions based on perceptions from the world and respond to other creatures' actions.

3.4 Agents General Structure

Agents are the most powerful creatures in Zamin model. Once an agent receives the 'Create' message, it also receives a link to the world module which can later be used to manipulate the world, directly and without supervision. A user of Zamin model needs to program an agent only when a major change in environment or its control is needed. As stated before, six agents are predefined in Zamin which control the general life cycle and control mechanisms, but as many necessary new agents can also be added.

Table 1. Simple Organisms' Properties

| Property | Description |
|-----------|---|
| Species | Specifies the species that this creature belongs to. |
| Name | The creature's name. |
| Age | The creature's age. |
| Position | The creature's location in world map. |
| Is Alive | Indicates if the creature is alive or is dead. |
| Energy | Indicates how much energy s/he has now. |
| Resources | The amount of resources that this creature owns. The resources are grouped in to 4 sets: 1. The absorbed ones which can be used to build up body, get energy or create seeds. 2. The resources that are now part of the body and can not be used for any other task. The body can be defined to have effects on other tasks, by the types and amounts of materials which build it. 3. The waist resources which are the result of previous reactions and must be gradually released. 4. The embryo resources which are gathered to produce seeds. |

Table 2. Animals' Extended Properties over Single Organisms

| Property | Description |
|--------------|---|
| Hatched | Specifies whether the organism is still in egg or has hatched out. |
| Sex | Organism's sex, which can be male, female, or asexual. |
| Pregnant | Tells if the organism is pregnant and producing some eggs. |
| Orientation | Specifies the direction of the creature's face, which can be up, down, left or right. |
| Attack Skill | Organism's performance in attacking another creature. |

| | |
|---------------|--|
| Defense Skill | Organism's performance in defending an attack from another creature. |
|---------------|--|

Table 3. Animals' Action Choices

| Action | Description |
|----------------------------|---|
| Hatch | A creature that is still in egg can make this request and get out of egg. |
| Move | To move to an adjacent location in the world. |
| Eat | To eat something and absorb its resources. |
| Turn | To change the animal's orientation. |
| Mate | To mate another animal or start pregnancy for an asexual animal. |
| Lay Egg | To lay some eggs. |
| Internal Resource Transfer | To transfer some of the absorbed resources to the body or the embryo(s) that will be put in egg(s). The resources that are transferred to body can define creatures capabilities, such as attack and defense skills, energy consumption, etc and can be ate as food by the other creatures, when the creature dies. |
| Communicate | To transfer a message to another animal or to broad cast a message. |
| Give Resources | To give some resources to another creature or an egg. |

Table 4. Animals' Received Messages

| Message | Description |
|---------------------------------|---|
| Create | A creature receives this message when it is about to be created. A genome may be enclosed by the message. |
| Choose Action | Each creature receives one 'Choose Action' message at each time step. The world view is enclosed by this message and can be used to select action and experience the result of the selected action. |
| Die | Once the creature is about to die, s/he receives this message. Even if this message is not processed, the creature dies. |
| Mating Proposal | Once a creature request to mate another creature, the second one receives this message and a view of the requester. The receiver can return his/her opinion on mating. |
| Mate Request's Result | Once a creature request to mate another creature and the second one replies his/her opinion, this message is sent to the requester to tell him/her the other animal's opinion on mating. Then, the requester can replay whether s/he wants to commit mating or not. |
| Get Genome for Mating | Once two creatures have mated, the male one receives this message to pass a copy of his genome for the creation of the embryo's genome(s). |
| Begin Pregnancy | Once two creatures have mated, the female one receives this message and a copy of male's genome to start pregnancy. |
| Get Resources & Genome for Eggs | Once an animal has requested to lay eggs, she receives this message to pass the genomes and resources for the eggs. |
| Text Message | Once an animal receives a text message from another animal, this message is received, enclosed by message's text and sender's identity. |

4 Experimental Results

The main advantage of the new model in compare with the previous one is the modularity. To alter something in the new model, in most cases, one just needs to re-write one message handler for one agent and re-register the agent; and for systems such as artificial life models which have many interconnected parts, this is a great advantage. To change a control mechanism or simulation approach in the previous model, all the changes had to be done in the main model and it had to be recompiled and rebuilt. This approach had two disadvantages: First, the designer had to find the part that had to be changed among the too many tasks that the main module had to do, and second, once the part to be changed was

identified, changing it could affect other parts because no task separation was mentioned in original design. But in the agent based model, a task can only be related to one agent and to change agent's behavior, only the necessary messages need to be processed.

To make a comparison, table four presents some comparisons between the tasks that had to be done in the previous model to reach to a certain design and what that can be done in the new agent based model. As it is shown in the table and our tests, the effort required to reach a goal in the agent based models is almost 30%-50% less in all our sample implementations which shows a good reduction over the previous model, while the capabilities are not reduced as well.

Table 5, Models Comparison

| Target | Old Model Tasks | New Model Tasks | CC1 ³ | CC2 ⁴ |
|---|---|---|------------------|------------------|
| <u>To create a new organism.</u> <i>Used in almost all experiments, such as (Zadeh, et. al., 2003), (Halavati et. al., 2004) & (Zadeh et. al., 2004)</i> | 1- Implement the abstract class for the new organism by implementing all required functions. 2- Change organism creation functions. 3- Change iteration control functions. 4- Change population control mechanism. | 1- Implement the new class by implementing the message map. 2- Register the new class. (One Command) 3- Add population control settings in the configuration file, <i>Lives' Lord's</i> section. | ~1000 | ~400 |
| <u>To change population control.</u> <i>Used in many experiments</i> | 1- Rewrite population control functions of the main module. | 1- Change <i>Lives' Lord's</i> settings in world configuration file. | 10-12 | 1-2 |
| <u>To implement a model for training speech phoneme recognizer agents.</u> <i>Used in (Halavati et. al., 2004b)</i> | 1- Implement the abstract class for the new organism by implementing all required functions. 2- Change the main module so that to give voice samples instead of food and give energy based on recognition capabilities. 3- Modify the main module so that to create new organisms of the type, when necessary. 4- Change the population control and iteration mechanisms to support this design. | 1- Implement the new class by implementing the message map. 2- Implement speech samples as a new simple organism. 3- Override <i>Actions' Lord's</i> message map and route 'EAT' command, so that it needs a phoneme guess as well. | ~1500 | ~800 |
| <u>To create agents with a new capability</u> <i>Done and reported in (Halavati and Shouraki, 2003)</i> | 1-4- As in first sample. 5- Modify the main module to add new capability and its mechanism. | 1-3- As in first sample. 4- Override <i>Action's Lord's</i> message map and support the new action. | ~1300 | ~900 |

³ Code Change in Old Model, in c++ lines.

⁴ Code Change in Agent Based Model, in c++ lines.

5 Conclusion and Future Works

Artificial Life is an approach to synthesis life to know more about and learn more from it. Zamin is an artificial life test bed, suitable for cognitive studies on evolution of complex behavior and decision making strategies and is used for different researches hence forth. In this paper, a reorganization of Zamin is introduced which is totally based on agents and can be easy to expand and alter. As stated in section four, this new model totally covers the previous one and having all its capabilities, it is quite more expandable and easy to modify. To show this, we have re-implemented some of our previous designs in this model and a coding reduction, around 30%-50% is reached. There are now two projects running on Zamin on evolution of social insects and training of human speech recognizers and will be reported soon. Besides, we are designing a Zoo of different animals in Zamin which can be used in ecological Simulations.

References:

- Barrett, L., Dunbar, B., Lycett, J., (2002) *Humans Evolutionary Psychology*, Palgrave, New York, USA.
- Halavati, R., Bagheri, S.B., (2003), Evolution of communication and its consequences, in: *Proceedings of International Symposium on Computational Intelligence and Intelligent Informatics (ISCIII'03)*, Nabeul, Tunisia
- Halavati, R., Shouraki, S. B., Zadeh, S. H., (2004) Evolution of Pleasure in Zamin Artificial World, *Proceedings of IASTED International Conference on Modeling and Simulation*.
- Halavai, R., Shouraki, S.B., Zadehh, S.H., Lucas, C., (2004b), Evolution of Speech Recognizer Agents by Artificial Life, Submitted to *Recent Advances in Soft Computing*, Nottingham, England.
- Hraber, P.T., Jones, T., and Forrest, S., (1997), The ecology of Echo, *Artificial Life* 3(3), 165-190.
- Langton, C. G., (1992), Life at the Edge of Chaos. In: C. G. Langton, C. Taylor, J. D. Farmer, and S. Rasmussen, (Ed.), *Artificial Life II, Volume X of SFI Studies in the Sciences of Complexity*, Addison-Wesley, Redwood City, CA, pages 41-91.
- Mascaro, S., Korb, K.B., and Nicholson, A.E., (2001), Suicide as an Evolutionary Stable Strategy, In: *Proceedings of the 6th European Conference on Artificial Life*, 120-132.
- Merks, R.M.H., Hoekstra, A., Kaandorp, J., Sloot, P., (2003), A Problem Solving Environment for Modelling Stony Coral Morphogenesis. In: *Proceedings of 3rd International Conference on Computational Sciences*, Saint Petersburg, Russia.
- Neumann, J.V., (1996), *Theory of Self-Replicating Automata*, University of Illinois Press, Illinois. Edited and completed by A. W. Burk
- Ray, T. S., (1992), An approach to the Synthesis of Life, In C. G. Langton, C. Taylor, J. D. Farmer, and S. Rasmussen, (Ed.), *Artificial Life II, Volume X of SFI Studies in the Sciences of Complexity*, pages 371-401, Addison-Wesley, Redwood City, CA.
- Zadeh, S. H., Shouraki, S. B., Halavati, R., (2003) Learning and Abstraction in a Fuzzy Artificial World, *Proceedings of IASTED International Conference on Artificial Intelligence and Soft Computing*, pages 75-80, 2003
- Zadeh, S. H., Shouraki, S. B., Halavati, R., (2004) Emerging Simple Emotional States in Zamin Artificial World, *World Automation Conference*.