Abstract: Zamin, is a general purpose artificial environment suitable for cognitive studies. This environment, which presents high-level agents in a rather complex environment, has been successfully used as a test bed for some AI researches, like cooperative learning. Although it still has some deficiencies, it has many useful features and in addition, it can be enhanced with some proposed features to cover more capabilities. We have prepare a survey on some recent researches in the area of Artificial Life to show the advantages of this environment in comparison with nowadays special purpose as well as general purpose simulated world test-beds. In addition we have tried to highlight its disadvantages that may be fixed by researchers that are interested in this subject.

Source code and documentation of both versions of Zamin (with normal as well as fuzzy learners) are publicly available on the web.

Key-Words: Artificial life, Case-based Reasoning, Fuzzy decision making, Immerging behavior, Genetic evolution.

1 Introduction

Cognitive researchers face the psychological, behavioral, social and genetic problems in a variety of ways. Alife is one of the most suitable research areas in the AI field for cognitive studies and many researchers have focused their study on this field. For this reason, many artificial environments have been developed. Some of these environments are simple and special purpose, and many of them are rich and general purpose.

Zamin[14], which has been developed recently, is a rather rich general-purpose environment, in which complex artificial agents can live and evolve. It has been used as a test-bed for several cognitive studies and has proved its capabilities as a well-designed artificial environment for being used in further researches.

Since developing a new Artificial Environment is a time consuming task, which needs a lot of efforts and takes the researchers’ energy and time, it seems not to be a wise solution. On the other hand, many of researchers prefer to configure a general-purpose test bed and make it compatible with their needs in a special study. This policy reduces the overhead of preparation phase of the research and makes the study less dependent to a special test-bed. In addition, using general environments helps others to repeat a study and test the results. For these reasons, we have tried to review the key features of Zamin and compare them with the features of recently developed artificial environments that have been used in this field. As a result of this survey, we will find out the advantages and disadvantages of Zamin, and the possibility of using Zamin instead of developing a new environment. In addition we will try to propose some extensions that will make Zamin more powerful and more flexible.

In the following sections, we will review Zamin and some other environments regarding the following key features:

- World complexity and behavioral abilities of agents
- Reproduction and genetic evolution
- Sensory capabilities
- Decision making policies
- Learning abilities
- Communication and coordination capabilities

We will refer to other researches by the name of the first author of referred paper enclosed in brackets. For example “[Mascaro][1]” refers to the work presented in reference [1] of this survey.
The interested reader can find our proposal for extending Zamin environment in the conclusion section.

2 World Complexity and Behavioral and Sensory Capabilities of Agents

Zamin[14] consists of a toroidal lattice in which three types of living objects live. These three types are:

- Aryos: the main bio-organism in the environment.
- Plants: that play the role of the food for Aryos. The number of trees in the field is limited (and so is the total amount of food).
- Predators: Hard coded organisms that do nothing but killing the Aryos!

Aryos can do one of the following actions at each time step:

* Move, Turn, Eat, Attack, Reproduce, Rest*

Whenever an agent runs an action, it gains or looses some amount of energy.

Aryos also have sensory mechanism that provides two types of sensory inputs for them:

- Internal sensory inputs that contain Aryo’s energy level, its age, and what it had done as the last action.
- External sensory inputs which specifies the type and properties of the nearest object in the visible field.

[Steven Mascaro][1]

Steven Mascaro and his coworkers have tested some psychological theories using their Alife simulation environment.

Their environment consists of a 40*40 board, which at most one entity can be at each cell. Certain food amount is available. Agents living in this environment are given a chance to run an action in each cycle of simulation.

Agents’ properties:

* Age, Maximum age, Health, Sex*

Actions:

* Eat, Walk, Turn, Rest, Consensual Mate, Rape*

As it can be seen, many of features of the environment are like Zamin. For example the world is again a lattice, and action selection is performed in each time step. Also each agent is aware of his age. The mechanism that changes the health of the agent is like the pleasure system in Zamin. In addition four possible actions out of six are currently available in Zamin environment.

The main differences between the two environments are:

- All of Aryos has the same sex but in this work agents are of two different sexes.
- Here there are two additional actions: Mate and Rape.

It seems that this work could be done using Zamin environment and much less effort is needed to revise Zamin such that it becomes compatible with this work’s requirements. However it is a good idea to add the possibility of having agents of two different sexes to Zamin Environment.

Regarding sensory information available for agents, there is a satisfying compatibility between this work and Zamin. The only main difference is related to mating requests that as previously noted requires some extensions in Zamin.

[Oboshi][2]

Oboshi and his coworkers have constructed a simulation environment to study some aspects of fish’s behavior, specially the schooling phenomena. For this goal they have assumed that a group of N fishes are living in a two dimensional world. This world is a 40*40 board, N prey fish and one predator fish exist in this world. If the population decreases, it is adjusted at the beginning of the next cycle.

Each fish can move in this world and its movement has two parameters:

* Direction, Speed*

Speed of the movement is chosen according to a Gamma-distribution. But the direction is a function of the movement quality of other preys or the predator. If a fish does not sense the predator, a direction is chosen that keeps the fish in the school. Otherwise, if the predator is sensed, the fish’s direction will be a parameterized function of relative direction of the predators. This function has four parameters that are in its genome and are main subject of evolution in this environment. The better tuned the parameters, the more chance of survive.

Each fish can sense nearby fishes and the predators presence at a certain field of view. In addition, it can sense the direction of sensed fishes and predator relative to its movement direction.
In comparison with Zamin, this environment is very simpler and its agents’ capabilities are less than Aryos, but the structure of the environment, like Zamin’s structure, has a lattice form. In addition there are only two types of living objects that match with Zamin’s bio-organisms that are Aryos and predators. The differences are that here there is only one predator and both preys and the predator do not need to eat at all.

If someone wants to replace this environment with Zamin, he should add only the direction and speed properties to the move action, and also the capability of sensing this information about other fishes.

[Sawada][3]
Takamasa Sawada and his coworkers have proposed a model of biological differentiation and tried to test this phenomena based on physical features and behavioral strategies using the Alife simulation of birds’ evolution.
There are two islands, each of which is a 50*50 lattice, and 120 birds exist in each island. The temperature changes to simulate the hot and cold seasons.

Agents can do one of these actions:
Move, Eat, Migrate, Rest

Agents are composed of two features:
• Physical attribute: thickens of the skin
• Behavioral activities

Agents have an upper bound for their age and a lower bound for their internal energy (state). Agents, also can sense their internal states and also the external stimulus. Their behavioral strategies are functions of these two sensory inputs. Each action has an effect on the agent’s internal state.

Birds can sense their need to eating, presence of plants or friends in a short distance, and also they know whether it is cold or hot. All of these sensory inputs are in 0/1 or True/Fake format and are assumed to be precise.

Again the lands’ structures are the same, and also the actions are very similar. The structure of agents seems to become identical, if physical attribute can be located in the genome of the agents. In addition sensory capabilities seems to be alike.

Zamin potentially has what is required here.

[Noble][4]
Jason Noble and his coworkers have developed a rich environment for testing capabilities of different learning method and their effectiveness in enhancement of social learning abilities.
They have constructed a 10*10 toroidal environment. Each square is empty at 20% of times.

There are the following objects in the environment:
• Agents
• Tools (stones, big stones, sticks)
• Resources (trees, nettles, etc.)

Actions are:
Move, Shake (a tree), Fold (a nettle leaf), Poke (a nest), Bash (a nest), Eat, Chase (a monkey), Throw (a stone), Rub (two stones), Scratch, Peel (a stick), Swap (a tool), Travel (to a most nearby resource)

Choosing an action may lead to a positive or negative payoff depending on the context.

There are about 10 resources at the environment, that differ in the degree of payoff that the cause. Some of them are easy to use, but have less positive payoff than those that are more difficult to use. Of course there are some resources that may be painful if a wrong action is used with them.

Every 400 time steps, a new agent is born and if there is 25 agents at the environment, the oldest agent in the environment will be killed. The agent that has been born 12 places ahead of the newborn one is considered as its parent.

Agents can perceive their local resources, other agents and the available tools. They also can perceive the resource type present in a certain neighborhood and also what other agents do in the environment.

This environment is really a rich one. It provides many different resource and action types. Although the land’s structure is again toroidal, the differences seem to be more than similarities. But in the case of sensory capabilities, the only difference is that in this work, agents are able to sense what other agents do while in Zamin, agents can only sense the presence of other objects and their type. In fact Zamin can be used as a base for this environment, but needs to be extended in order to provide this variety of actions and resources.

[Channon][5]
Geb environment introduced by Channon et.al. [5] is also a two-dimensional toroidal grid world of artificial organisms each controlled by a neural network. A usual environment contains 20 * 20 cells. No two individuals may be within the same square at any one time. Agents have the following properties:

Size, Direction, Position

They can perform these actions:
• Try to reproduce with organism in front
• Fight: Kill organism in front (if there is one)
• Turn (anti-) clockwise
• Move forward (if nothing is in the way)

Here there is just one kind of agents, so presenting a simpler environment than Zamin. Some behaviors, which are evolved and dominate the population here, results in very simple strategies such as 'do everything' and 'always go forwards and kill'[13].

The sensing mechanism in Geb agents is quite abstract: an organism’s network input nodes have their excitatory inputs set to the weighted sum of 'matching' output nodes' excitatory outputs from other individuals in the neighborhood. This is far from simulating a natural environment. Currently the sensory input is a 5 x 5 neighborhood area centered on the relevant organism.

Here no explicit communication or sensing of a natural property exists. Geb agents are more like being Cellular Automatas, except for that they are evolved to produce rational behavior.

[Adami][6]
Avida is the most widely used Digital Life platform today [Adami][6]. Because of the exibility of avida as an experimental platform, it has been used to address a wide variety of problems in the evolution and dynamics of simple living systems.

World geometry has been chosen either as a two-dimensional grid that wraps on itself (at torus) in order to avoid boundary effects, or else a well-stirred reactor without any geometry. In both cases, the world is isotropic and homogeneous, i.e., it is a single-niche environment (see Fig. 1).

In avida, a standard instruction set of 28 different instructions is usually used, which is superficially similar to Intel i860 assembly instructions, liberally supplemented with instructions that allow self-replication. Examples of such instructions are copy, which copies an instruction from one memory location to another (and which has a probability to fail set by the mutation rate), allocate, which allocates memory space before replication can begin, and divide, which separates a mother and daughter program and places the daughter, either near the progenitor on the grid or anywhere, depending on the choice of geometry. Other instructions manipulate the virtual CPU's registers and stacks, and perform logical, bitwise, operations on random numbers that are abundant in the organism’s environment.

Avida works with intelligent agents who are due to evolve and introduce novel and maybe optimal solutions for a problem, using genetic programming. It models energies for agents in the form of “Resources”, lack of which can lead to starvation of some part of the population. At the same time, it appears reasonable to propose that performance of a computation in the presence of the enabling resource might transform the resource rather than use it up.

B -> NOR -> C

In this way, different species can appear and some may invade others.

Here, agents can get more and more complex; they can show the complex behavior of Aryos. However, they are not as natural as Aryos, since there is no meaning of an agent, but a program, which can get its input data and produce its output.

Aryos are not as complex as Avida agents, since they are composed of low-level instructions.

[Burkhart][7]
Swarms are composed of agents moving randomly over a two dimensional lattice. Swarm allows users to explicitly build and test multi-level models. A swarm can explicitly represent an emergent structure, a group of agents behaving cohesively as a single agent. Because swarms can be created and destroyed as the simulation executes, Swarm can be used to model systems where multiple levels of description dynamically emerge. Various types of entities can exist in an environment, coyotes, rabbits, a garden with carrots, etc. with their specific schedule of activity. In Swarm, agents can themselves own swarms, models that an agent builds for itself to understand its own world. The modularity and composability of swarms allows for a flexible modeling
system. Swarms can be nested to directly represent multi-level simulations, and they can be used by the agents themselves as models of their own world (Figure 2).

For example, [Mason et.al. 2002] uses stigmergy to reproduce and analyze termite's emergent behavior, like pillar-making behavior and ant's foraging and the spontaneous cemetery building. The agents are identical and stateless. Actions performed by agents are:

- Releasing a pheromone
- If a brick is carried, dropping it

In this example, curves, star-chains, and other structures are built by these agents (emergent behavior). The environment and the agents are quite simple compared with Zamin. They have no learning capability and use fixed decision making policies. If an agent detects levels of certain pheromones within certain ranges, it takes a given action. Pheromones can be enablers or suppressors of a rule. In some applications, like pillar construction behaviors, agent properties can be modified; for example, in [Swarm ref], an “stabilizer pheromone”, which tells passing agents that a brick has been dropped purposefully, and that they should therefore not pick it up, but placing bricks nearby is introduced in the environment. Structural rules generally create small activation potentials in order to precisely place future pheromone deposits.

In Zamin one can add custom actions by programming. Swarm environment is very simple and considers low-level behaviors of simple entities, while Zamin is suited for more high-level activities in intelligent agents.

[Mesot][8]
Mesot and his coworkers in [8] have evolved trail follower agents in a simple environment of empty of food containing grid cells. The body of the agents is not evolved, but is predefined. The behavior of each agent is controlled by an FSM, which can be simple or hierarchically constructed on top of complex actions (simple FSMs). This representation gives a much higher level of interpretability when compared to neural networks.

Agents’ have State-action tables, which are evolved genetically and fixed during its life. The agent can:

- Turn right or left
- Step forward 2 steps and then return in the opposite direction to the departure position.

Some other high level actions are also learned by FSMs and used in hierarchies. The only sensory information is whether the cell ahead contains food or not.

The environment is very simple. For example in the implemented application, the behavior that the agent is due is known in advance: optimally inspect the neighbor cells and move to them if food is available. This environment can be used in multi-agent simulations as well, as a simple environment. As we will see later, the learning mechanism in the agents is quite flexible, however, as it has some genetic evolution as well as learning phases, it takes very long to reach acceptable FSMs.

[Standish][9]
EcoLab[13] is an evolutionary ecology, and is mentioned to be the first published account of population dynamics being linked to an evolutionary algorithm.

This experiment involves modifying the mutation operator to bias it towards adding or removing interaction terms, which adds or removes food connections. Specialist agents have a few links to types of foods and predators, while generalists have more links. So specialists may easily extinguish in the lack of a specific food resource, while generalist may not. There is a reverse relation between Diversity of species and Generalities of species. Having more specialists means the desirable result of having more diversity in the evolution results. Eco Lab has delivered a result of a “resonance”, where if the migration rate is tuned to this value, diversity grows exponentially.

This world is mostly used for analyzing population dynamics. Agent properties and actions are selected as of in usual artificial worlds.

[Bayazit][10]
This is a somehow different world than the previous ones. In this environment, the flocking behavior of agents is discussed. There are a number of rules associated with regions of the Environment and are stored in roadmap Nodes. These rules describe Agent behaviors. They can contain variables, assignments, control statements and loops. Triggers are special rules, which are invoked to initialize and finalize variables governing behaviors. For example, in the narrow passage behavior, the first Agent to reach the passage is
selected as the leader by the Trigger for that narrow passage.

Agents have **Position, Goal, Role, Path** as their (dynamic) properties. By defining proper rules, the authors have considered four behaviors: homing, goal searching (Figure 3), traversing narrow passages and shepherding in agents. For more clarifying the environment, a naive way to achieve narrow passage traversal by the flock is briefly described; it can be achieved by using the homing behavior and then, to select two nodes as goals; first a node in front of the entrance to the passage and then a node outside the exit from the passage. One drawback of this approach is that flock members may bunch up and conflict with each other as they try to move through the passage. A follow-the-leader strategy may avoid the congestion problems of the naive strategy. The rules are fixed during the simulation and are designed by the user. The agents have no sensory information, but the global information provided by the simulator. Like geometric center for the flock which is used in shepherding. Communication is also indirect and through the environment.

As the behavior algorithms are fixed, this is a novel environment and can be used as a dynamic environment to evolve agents in. Aryos may communicate with each other using the environment, by putting signs on them. It seems reaching high-level behaviors of the type discussed here may be achieved by adding some predefined rules, and try to learn or evolve other rules.

![Figure 3: Ten flock members are searching for an unknown goal. (a) The flock faces a branch point. (b) Since both edges have the same weight, the flock splits into two groups. (c) After dead ends are encountered in the lower left and upper right, edge weights leading to them are decreased. (d) As some members find the goal, edge weights leading to it are increased. (e) The remaining members reach the goal.](image)

[Mitteldorf][11]

This environment is an n x n viscous grid, divided into a number of sites. Predators and preys are bined to sites; adjacent grid sites are connected by slow, random migration of both predators and prey, allowing or between-group competition in exportation of migrants.

A number of variables can control large scale properties of the environment, like:

- **K** controls the maximum number of prey that can be supported at a site in the absence of predation.
- **r** is the time scale for exponential increase of the prey population in the absence of predation.
- **d** is the time scale for exponential extinction of the predator population in the absence of food.

Predators have these properties:

- Maturity
- Appetite
- Migration probability, if higher than 0.03, globalization is produced
- Threshold for reproduction
- Accidental death
- Cost of living

The sensory capabilities of the agents are similar to other predator-prey artificial worlds. Various evolutionary parameters can be changed and examined in this environment, which is very similar to large scale societies, like neighbor cities, or social groups. For example, the authors have explored these parameter effects:

- Effect of varying migration rate
- Effect of varying per-site carrying capacity
- Variable mutation rate

They have shown that over a wide range of parameter values, group selection can compete effectively with individual selection to temper the pressure toward an unsustainable level of exploitation.

In this domain, ecological properties of societies with various structures and configurations can be analyzed.

### 3 Reproduction and Genetic Evolution

Since Aryos do not have different sexes, in Zamin, reproduction is performed asexually. In addition agents
should have enough energy and also decide to reproduce otherwise no reproduction will happen. Aryos have genetic information in their genomes. This information consists of pleasure mechanism of the agent that says how much pleasure does the agent gain in each state of the environment. In addition some of behavioral or internal parameters of the Aryos are defined in their genomes. The genetic information of Aryos is subject of some mutations using the reproduction process. The degree of these mutations is defined in the genome. No cross over happens because the reproduction is an asexual process here.

[Mascaro][1]
In the work of Steven Mascaro, two agents of different sex that have enough health are required for reproduction process. The offspring will have a combination of its parents’ genomes. Since this genome contains the behavioral patterns of parents, recombination will result in a new set of production rules. Recombination of production rules is performed using multi-point crossover. This evolutionary process helps the better behavioral patterns (that lead to more healthy parents that are capable of reproduction) to remain in the world. As we mentioned previously, the only and main difference between genetic evolution and reproduction of these work with Zamin, is that in Zamin, Aryos have the same sex, but here Agents are not of the same sex. If problem can be solved, then other features of genetic evolution will be identical. But at the moment, Zamin can not be used directly.

[Oboshi][2]
Four movement parameters are stored as the 10 bit genes in a fish’s genome. The evolution process causes these parameters to be adjusted such that the best direction for movement be chosen whenever a fish faces an urgent situation. The efficiency of the set of parameters in a fish’s genome can be measured using the number of cycles that it can survive before being killed by the predator. This value will be the fitness of that special fish. Once the population decreased by the predator, reproduction is happened. Here, two parents are required for each reproduction. An individual chance to be chosen as a parent is proportional to its fitness. One point cross over is used for each of four parameters in genome, and 5% probability is assigned to mutation of each bit of a chromosome.]
Here, again, the main difficulty is that Zamin only support on sex for agents. The fitness of fishes are a function of their life time, that is somewhat similar to natural selection in Zamin. This means that the only change needed is adding the ability to support more than one sex to Zamin.

[Sawada][3]
In Sawada’s work, the two main feature of an agent – which are physical attributes and behavioral strategies – are stored in their genome. During the reproduction process these features are combined in cross over manner and then a mutation process takes place on the result of cross over operator. Reproduction may happen only when the genomes of the two parents are similar enough. The conditions are just like the Oboshi’s work’s reproduction and genetic evolution features.

[Noble][4]
In the work of Noble and his coworkers, there is no genetic evolution. Each new agent, has to learn the ways in which it can gain more positive payoffs. For this goal it uses individual learning, and one of social learning methods. Although each agent is assigned a parent, there is no genetically relation between them, and the agent that is the parent, in some social learning methods, is used as a behavioral model for its child. Zamin is completely enough for this part of Noble’s work. For using Zamin here, we can simply make the genome empty of any information.

[Channon][5]
Evolution is strictly by natural selection. Reproduction involves crossover and mutation. Geb’s crossover always offsets the cut point in the second individual by one gene, with equal probability either way, which is why the genotype lengths vary. Mutation at reproduction is a single gene-flip (bit-flip). There are no global system rules that delete organisms; this is under their own control. The ‘new’ successor (if it exists) is a new node. It inherits a copy of the old node’s input links unless it has a link from the old node (b3 or b4). It inherits a copy of the old node’s output links unless it has a link to the old node (b5 or b6). A valid rule is one that starts with 11 and has enough bits after it to complete a rule.
Development takes place throughout the individual's life, although necessary limits on the number of nodes and links are imposed. This natural selection evolves both the structure and the values for the behavior structure. Since NNs are very flexible, it seems efficient and novel structures can be evolved in Geb. Multi-step decision making is an advantage over Zamin environment.

[Burkhart][7]
Decision making is done by using predefined rules. Entities do not learn. Agent actions as we saw are more simple. Rules are just evolved, but not adapted in learning processes.

[Adami][6]
There is running a program of instructions that play the role of an agent in other environments. Let us imagine, for the moment, a simple world in which there are only three different possible tasks, say performing one of these actions on two values: and, or, xor. Then, we associate resource “A" with AND, “B" with NOR, and “C" with XOR. We can now load up the world with these resources, and we can limit them. For example, we can stipulate that every time an organism performs an AND, a certain amount of resource A is depleted, and similarly for the other resources.

Genetic programming is used for evolving the very flexible agents in Avida environment.

[Mesot][8]
In SOS++, the fitness of each individual is calculated as a function of its learning capabilities. This value is then used to determine the individuals authorized to reproduce. In reproduction, some state-action from one agent are combined with state-actions from another one.

Learning capability is determined by the reward the agent has taken (number of food collected, vs. number of moves).

In order to be able to process genomes of different size: the total population is now distributed in several islands, the inhabitants of each island having all the same size of genome, different from that of the other islands. Regularly, after a given number of generations, a given number of the best individuals of an island emigrate towards another island, thus exchanging their advantages. The sizes of the migrant genomes must adapt to that of the destination island: if it is smaller, the genomes are cut; in the other case, random genes are added. In all the cases, all the individuals of an island preserve the same size.

[Bayazit][10]
This environment is used for showing complex group behavior in agents. Rules are predefined and do not evolve.

4 Decision Making Policies
In Zamin, Agents decide what to do, using their action selection knowledge. This knowledge is composed of their inherited action selection rule set and their knowledge about their previous experiments.

Agents inherit a rule set that is a subset of action selection knowledge of their parents.

In addition they have a bank of previous state-action pairs and the pleasure assigned to them. This pleasure value shows the amount of pleasure gained by doing that action in that state. The state information can be stored in fuzzy form.

If the current state is not completely identical to the state of previous experiments, the most similar experiments are selected and according them, the most suitable action in current state is chosen.

The number of experiments that may be stored or inherited can be defined. Also a cost may be assigned to the larger sizes of this storage.

In addition, some inaccuracies man be added to decision making process using some noise parameters defined in genome or fuzzy extension of decision making process that is now available in zamin.

[Mascaro][1]
In Mascaro’s work, All decision makings are according to seven rules available in the agent’s genome. These rules accept some sensory inputs and propose an action to do. For this action selection, rules are checked in random order, and the first rule that matches the current state of the agent (according to sensory inputs) will be fired.

This action selection mechanism, is much simpler than what is available in Zamin. It is clear that if we limit the experiment bank in Zamin to seven simple constant rules, the action selection of this project will be simulated.

[Oboshi][2]
The only decision that a fish can make is that which direction and speed is chosen for movement. The speed
is calculated freely but the direction depends on parameters that are inherited. In addition, using probability distributions, some inaccuracies are added to decision making process. Here, there is no inaccuracy, and the decisions made can be completely determined according to the state in which the fish is. So there is no need to complex process of decision making in Zamin, and its better to use the simple straight routine of fish decision making.

[Sawada][3] Each bird has a decision tree in its genome according which it decides what to do in each cycle of simulation. For this sample, the information needed for decision making can be stored in Zamin’s organisms’ structure and Aryos’ decision making process can be completely ignored.

[Noble][4] Choosing the actions is performed based on the history of reinforcements. The action that has the highest payoff at the current state is chosen. As it is clear, this process is the same as Aryos’ decision-making system. So in this part of Jason’s work, the Zamin’s mechanisms can be used without any changes.

[Channon][5] Production rule matches a node if its predecessor is the start of the node’s character. The longer the matching predecessor, the better the match; the best matching rule (if any) is applied. Thus ever more specific rules can evolve from those that have already been successful.

[Swarms][6] Simple and fix rules are used in swarm entities. These are used by a swarm that for example generates a left-curving arc of bricks. Each rule will deposit a pheromone at a point new that is an estimated distance near newdistance from the deposit nearsource, where nearsources a distance far nearsource from the deposit of farsource. The angle between the first vector and the perpendicular of the second must make an angle from perpendicular, as illustrated in Figure 4. Rules that use local pheromone intensities to estimate the distance to the nearest deposit are inherently vulnerable to interference from other, unexpected deposits. Since interference diminishes with distance, this problem can be worked around by building rule-sets that keep deposits of each pheromone widely separated. Rules are fixed and simple, although resulting in complex social behaviors.

[Adami][6] Decisions are made by running of genetic programs, which could be quite complex. organisms with sequence lengths of several hundred instructions performing a good fraction of all possible computations readily emerge in the experiments.

[Mesot][8] There is a single action associated to each state, as this is the case for a Moore FSM-Moor. Therefore, we must suppose that the state-action associations are the right ones. Indeed, we achieve this by using a genetic algorithm. The value of a gene is an integer indicating the action associated to the corresponding state. The learning will be given the responsibility to interconnect needed states, leaving the other states without connection. Executing actions regarding each state and sensory information received from the environment.

[Bayazit][10] Controlled by global simulation, and taking the actions specified in fixed rules in the environment.

5 Learning Abilities
In Zamin, each agent saves the current experiment in his experiment bank and uses this saved information to decide to do which action at next decision-making steps. In addition to storing the experimental information, Aryos can do generalization and abstraction tasks on this information in order to collect more useful decision making data.

[Mascaro][1] Since all actions are selected using a hard coded decision making system, there is no learning mechanism embedded in this simulation environment. The only learning mechanism is the natural selection that affects the behavior during the species refinement process. Since there is no learning ability here, Aryos’ learning mechanism is useless here. If one wants to use Zamin, for this part of work, he may disable the learning
mechanism, and put the decision making instructions in the agents’ decision-making knowledge.

[Oboshi][2]
In this artificial world, agents act just as their genome says. So there is not any learning process using which individuals can improve their behavioral and decision making abilities. Here, conditions are like the Mascaro’s case. For using Zamin, one should disable learning process and put the knowledge of decision making in the agents’ genetic code.

[Sawada][3]
Instinct defines the actions that the agent had to do. So there is no learning in agent’s life. Here, again there is no need to a learning mechanism.

[Noble][4]
Agents can use several learning methods during their lifetime. The first method which is used by all of the agents, and is an individual learning method is Q-learning. In this method agents associate to every previously experimented state-action pair, a certain payoff value (reward or punishment). In addition, for computing these payoff values, agents take into account not only the immediate, but also the delayed payoff value for each state-action pair.

In addition to individual learning, several social learning methods can be used. These methods are following, contagious behavior and emulation and imitation. Also following method, combined with each of the others is used as combined methods.

Although all agents use the same individual Q-learning method, several social learning approaches have been implemented for this work. If one wants to use Zamin, he should extend its social learning abilities, but can use Zamins inference engine’s infrastructure as a base for this extension.

[Mesot][5]
Agents use a genetic algorithm to find the set of states-actions pairs used by the learning algorithm. A variation of the reinforcement learning, a learning algorithm well known in the field of neural networks, is used to dynamically build the interconnections between the states. Some of the learning parameters are also calculated by the genetic algorithm.

The state of the environment is not coded, but, quite simply, values from some of its parameters are used (those which are accessible to the input organs or sensors of the agent). These inputs of the agent (perceptions) will allow it to change its internal state: we thus learn the states of the agent’s controller and not those of the environment.

To learn now means to find the appropriate transition between two states of the agent for a given input.

6 Communication and Coordination Capabilities

Currently, Zamin does not support communication among Aryos. Although coordination can be implemented among agents using their sensed data and individual knowledge, for developing complex cooperative some new communicational abilities should be added to Aryos’ features.

[Mascaro][1]
Although in this environment, agents’ behaviors have important effects on the other members of population, their communication capabilities are limited to mating requests.

As we noted before, Aryos have no communication ability, and cannot be used for this part of research.

[Oboshi][2]
Here, each agent, only senses the others, and no direct communication takes place. Although there is a total coordination among the members of population, this coordination is the result of actions of each agent based on its own observations and without any explicit agreement on that. Since Aryos are able to see others, it seems that this part of Tamon’s research can be implemented using Zamin’s infrastructures.

[Sawada][3]
Agents are aware of presence of the others. But it cannot communicate with them. Here, like the previous sample, Agents have no need to be specialized in communicational tools and Zamin seems to be completely enough.

[Noble][4]
There is no direct communication although there is some predefined behaviors such as imitation in which the agent uses another agent as a behavioral model, and this causes a simple coordination between two agents. For this part of Noble’s research, agents need not only to see the other agents, but also to understand what other agents do. The former part of this requirement is currently available in Zamin, but to have the latter one, some extensions is necessary for Zamin. Communication in Swarm, Avida, and Bayasit is through the environment: The primary advantage of this approach is that stigmergically controlled agents have minimal communication and no coordination overhead. EchoLab environment does not support communication.

7 Summary and Conclusion
In this review, we compared Zamin – a newborn artificial environment suitable for cognitive studies – with some other artificial environments that have been developed recently, some of which are very simple and the others, are complex and rich environments. This review covered the following key features:

• World complexity and behavioral abilities of agents
• Reproduction and genetic evolution
• Sensory capabilities
• Decision making policies
• Learning abilities
• Communication and coordination capabilities.
These comparisons show that almost all of simple artificial environments can be implemented using Zamin –directly or with very little changes. On the other hand, complex and specialized environments cannot be implemented using Zamin features, unless some important features are added to Zamin. After all, it seems that if the following features are added to Zamin environment, then Zamin will become a suitable environment to be used by researchers as an infrastructure of required artificial environments:

• The communication abilities using which agents can inform others about their goals, behaviors, requirements, etc. This goal can’t be achieved unless some global agreement or communication protocol could be defined among Aryos.
• General action definition abilities that help the user to define special actions by only configuring the general form of actions. This feature reduces the extension time needed for specializing the Zamin environment and made the configuration phase of Zamin, easier.
• Adding the ability of definition of two sex for Aryos will help those researchers who like to test their theories in an environment in which natural two-sex form of societies live.

In addition, adding these abilities to Zamin, will make this environment a more suitable test bed for cognition studies and it will be possible to test many ideas directly on Zamin environment without any extension on it.

References:


