On the Abundance of Energy Sources and Evolution of Collective Swarm in Auto-Constructive Artificial Life

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Abstract

We demonstrated a collective swarm of flying agents simulated in Breve auto-constructive artificial life, where their behavior is governed by its own simple set of programs expressed in Push programming language. Agents are programmed to seek the food sources to re-grow their energy as a main goal to survive for the next generation, thus collective agents may be capable of reproducing their own children. In this paper, the main concepts we are trying to get across concern on how reproductive competence may be affected by the quantity of food energy moves through an environment. We performed 50 runs test per parameter setting and will eliminate at 6000 generations each run. From the result, we found that the more increasingly the quantity of food energy are injected would encourage the more increase in the percentage of reproductive competence achieved within 50 runs. The reproductive competence means the point in which generation agents are able to reproduce their own children for the next generation without any new agent been injected.

Keywords–**Swarm Behavior, Collective Intelligence, Artificial Life, Auto-construction, Genetic Programming, Parametric Analyses**

Introduction

Artificial life refers to creating and simulating the living system to model life form, which can be implemented in computer. Artificial life also is defined as “life made by human”. The main purpose of Alife is to create synthetic life in an artificial component and compare it with the natural life, as we know it [1]. Alife has a great potential to explore especially in context of self-reproducing system.

Nowadays, a number of self-reproducing systems have been explored. In 1940, Cellular Automata (CA) environment was invented by John Von Neuman who created a set of rules describing how in one specific state of the system a particular configuration of cells is to be transformed or converted to another state of the system. One of the most well known CA rules, namely the ``game of life", was conceived by Conway in the late 1960s.

From this drawback, many researchers come out with their own system to model life form through computer simulation. An example of open-ended selection was Tierra, which was a simulation of evolving self-replicating programs with a mortality queue to ensure they had to try and copy or maintain themselves [2]. Similar to Avida and cosmos, where Avida was inspired by Tierra system that; relies on external mutating mechanism [3]. These systems must be seeded initially with the simple human coded self-replicating program. This is in contrast with Breve auto-constructive evolution, which relies on the Push program to support self-reproductive “PushPop” program in which the higher performance individuals are able to reproduce their own children [4].

By applying Breve application provides us a powerful framework [5], we presented a set of collective agents in 3D simulation. Over the years, one of the main difficulties that a user faces is on how to decide an appropriate set of parameter values, as user has to specify a number of parameter when applying a Genetic Evolution Algorithm.

Thus, evolved dynamic parameter values of food energy, which is defined as feeder in Breve simulation. The aim of this work is to investigate how the energy sources in environment would have an affect the reproductive competence in auto-constructive artificial life.

Methodology Approach

Breve environments

The swarm intelligence of flying agents was presented in 3D simulation using the piece of software called Breve environment. This system provides a framework for artificial life that can create realistic object in 3D simulation and includes a simple programmable language such as “Push” language for use in evolutionary computation [5].

The behavior of each agent in simulation environment was governed by one complete code program expressed in Push programming language. Push program has a simple syntax and can process multiple data types that allow Push to support the automatic evolution such as “auto constructive evolution. Thus, the genetic operator and other evolutionary system evolve themselves.

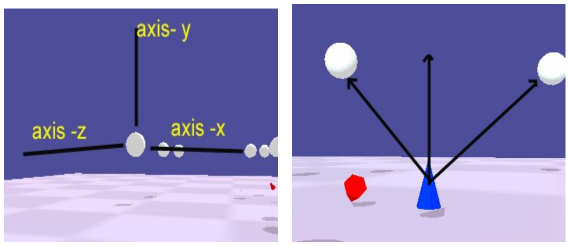
Auto-constructive evolution is a framework for evolutionary computation system [6], an evolving population of programs expressed in the Push programming language. This system is responsible for producing a new program through the mutation process for the next generation and evolves within the individuals as the system run.

Experiment setup

Characteristic of feeder

The environment in this simulation will be supplied with the needs of organisms such as energy sources are defined as feeder. Feeder is simulated in white sphere and contains energy that needed by agents as food to increase their energy and also for longevity. As shown in Figure1.0 (a), the movements of feeders were in limited areas and horizontally either axis-x or axis-z the movement on the axis-y (dot line arrow) and were not included to avoid the difficulties of seeking for food.

The agent with polygon shape in simulation as shown in Figure 1.0 (b), was programmed to fly and close the food energy with the aim to re-grow energy.



(a) (b)

Figure 1.0: (a) The direction of feeder moving to axis-x and axis-z.
(b) The direction of agents moving to the nearest food sources.

Parameters that were altered

Dynamic parameter refers to the number of feeders injected into Breve simulation. As shown in table 1.0, five different numbers are evolved before and after the point of default value. By applying this parameter value, we would like to investigate how this different number of food would have an effect on the reproductive competence in auto-constructive artificial life.

Parameter Values	Ranges
10	
12	
14	
16	
18	
20	**Default Value**
22	
24	
26	
28	
30	

Table 1.0: Parameter values are altered

Before running the algorithm, for each parameter values we performed 50 runs with 50 different seeds and will be eliminated at 6000 generations.

Reproductive competence

Each agent represented a complete Push program that will be evaluated. Agents were programmed to seek for food in order to increase their energy. Unsuccessful agent will quickly die thus the number of agents will decrease.

If the number of agents falls below user-defined threshold of 10 individual, the system will automatically inject new agents into the system in order to maintain the minimum population size. If this phenomenon occurs to the next generation, then the swarm in that particular point of generation will not be considered to be reproductively competent. Alternatively, if this phenomenon does not occur, agents may be capable to reproducing their own children, in which case the collective swarm will be considered to be reproductive competent.

Measuring reproductive competence

We measured the point in times where reproductive competence is achieved within 5500 generations completely without any new agent injected into simulation as shown in table 1.2:

Components	Feeder	
Dynamic Parameter setting	10(x 50 runs)	
Generations	Agents generated by:	
	System	Agents
1	1	0
2	0	0
3	.	1
4	.	.
5	.	.
.	0	.
.	1	1
.	1	0
456	0	1
.	0	0
2356	0	0
.	0	1
3564	0	1
6000	0	0
Average	(456 + **……..** + y)/ N	
Percentage	(N/50)*100	

N = The number of runs which the reproductive Competence achieved.

Table 1.2: The way to measure the reproductive competence

Result and discussion

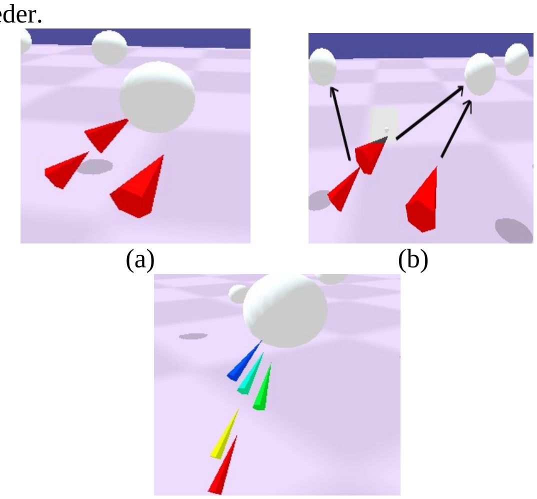
Table.1.3, displays a set of reported data on the mean and standard deviation of reproductive competence achieved within 5500 generations in 50 runs of test. As statistics, average refers to the measurement of the central tendency of the data set of reproductive competence and in relation to the mean we also measured the standard deviation of how spread out are the data values aways from the mean.

According to this table, the smallest value of mean shows the reproductive competence achieved earlier where agents are able to reproduce to make their own population for the future generation without any new agent randomly being injected. This can be seen at parameter 12 with average of 2 rather than 303.00 at parameter 10.

Parameter	Mean	Standard Deviation
10	303.00	0.00
12	2.00	0.00
14	300.00	164.01
16	181.38	140.10
18	165.54	166.76
20	180.91	178.24
22	130.14	154.31
24	151.14	149.14
26	189.12	194.86
28	190.40	198.42
30	186.17	195.38

Table 1.3: Average of reproductive competence within 5500 generations

From our analysis, this may due to the cause of the distribution of food energy located near the group that could have been caught by agents. As we can see the behavior of agents in Figure 1.2(a), even if a group of agents compete with each other but the same species (same color) among them will share energy to their friends. Thus, unsuccessful agents with less energy will get additional energy from their group's friend that would give it a chance to find food energy nearby Figure 1.2(b). However, if a group of agents were different species that is different color as shown in Figure 1.2(c), because of their rest energy that could not catch a nearby feeder.



(a) (b)

(c)

Figure 1.2: Behavior of collective agents:

Figure 1.3, showing the percentage of reproductive competence achieved within 50 runs. As we can see, the percentage of reproductive competence achieved at axis-y increased slowly against dynamic parameter values of feeder but suddenly showed a large difference at parameter 20 of 20% from parameter 18. This may due to the quantity of food more than agents that cause less competence among agents. Similarly even a 2% decrease at parameter 22 instead of at parameter 20 after 44% runs, we also found that the mean of reproductive competence shows the better result of 130.14 rather than at parameters 26 and 28.

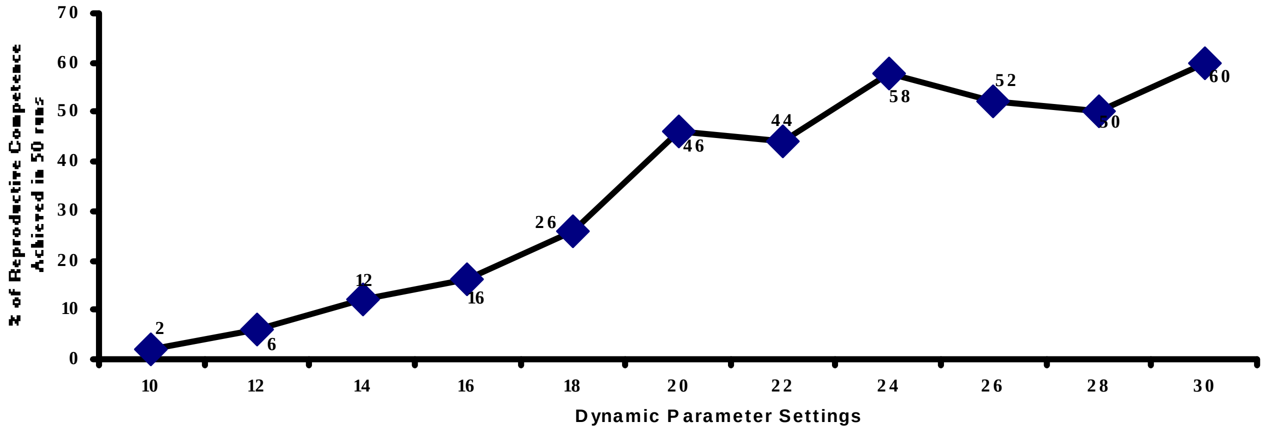


Figure 1.3: Percentage of reproductive competence achieved within 50 runs

Conclusion

The elements that appear in this work are focused on the main aspect on how reproductive competence may be affected by the quantity of food energy moves through an environment. The most specific approach is on the population of energy sources analysis, which estimates the energy budget of a particular population. The analysis is done by determining the amount of energy in the form of organic matter that is consumed, assimilated and excreted by individual organisms. The second approach is the study on the capability of each individual organism to survive, how fit are these individuals in competing with each other. In summary, the dynamics of energy in environment, each of which has its own inherent strengths and weaknesses. There are many other factors that would also affect the growth of population in environment. This would be interesting to explore for the future work.

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