Love of Evolutionary Shrimp

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Premise

The author developed a software that simulates an evolutionary ecological system of a shrimp colony equipped with 3D visualization. Each individual owns genetic codes of both appearance and preference to help effective mating inherited from parents to children with crossover and mutation. Some hundreds of individual shrimps are roaming, eating, swimming, and sometimes making intercourse in a virtual 3D space. By controlling the pose of camera as it tracks a sampled individual, it shows a closeup of what they are doing.

1. Why Shrimp?

This software was developed by the author as one of the artworks exhibited in “Volcana Brainstorm [1]” organized by Elena Knox in an art festival of Koganecho Bazaar 2019 [2] in Yokohama, Japan, from September 20 to November 4. Knox organized discussion meetings to pursue an artistic solution to help shrimp in “ecosphere” for their reproduction that would be realized the true sustainable micro ecosystem. The exhibition was by a collection of artworks inspired through the discussion by totally 42 artists of a variety of forms. The ecosphere is a commercial product that packs shrimp, algae, bacteria, and sea water together in a closed acrylic sphere [3]. It was inspired from a challenge of a NASA’s project to develop a method of travel by the space ship for a long time around the planets in the solar system and beyond [4]. Although this micro ecosystem would also be expected sustainable through a type of biochemical cycle, it ends with the shrimp’s death as they do not reproduce their offspring. One of the ideas by Knox was to produce a pornography for shrimp that makes them feel sexy to promote their mating. Her idea was also inspired by the history of Koganecho that used to be a dangerous area in the downtown occupied by a number of illegal underground businesses during the chaotic era after the end of World War II. The exhibition place is also a house where a number of girls were working in sexual services. The piece introduced here is an author’s answer that shows scenes of reproduction in the lives of shrimp in a virtual world.

2. Shrimp’s Life Cycle

From the view point of biological taxonomy, shrimp is a subgroup of Decapoda together with crab and lobster. The shrimp employed as heroes in ecosphere is “Halocaridina rubra” whose other name is Hawaiian Volcano Shrimp or ‘ōpae‘ula. They are tough enough to survive in a severe environmental condition and easy to feed in a normal tank. The wild colonies are found in brackish water pools near the sea shore in Hawaiian Islands.

Fig 1. A photo of a colony of shrimp in an anchialine pool in Hawaii Island, excerpted from youtu.be/Sa9sA-UMLPg in Opae Ula Related.

They are getting nutrition by eating algae and detritus. The female of this species lays 20 - 30 eggs, and holds them until the incubation. As similarly as the other arthropods, they grow through metamorphosis from larvae to adults. Some details of the life cycle of the species can be found in the page of Wikipedia [5].

3. Model of Behavior

Instead of modeling sensors, actuators and neural circuits that controls the individual behavior, a simpler computational model is employed so that individual behavior takes one of eight modes, floating, roaming, swimming, hungry, eating, sex, dazed, and dead. This is an extension of the author's previous work under a collaboration with Daniel Bisig [6].

A larva is usually floating under water, as it spends a planktonic life, then roaming on the bottom surface of the pond after grown up to adult. The adult individual seeks a partner during it is roaming, according to the observation of the neighbors' figures. When it finds a target as a new partner whose appearance matches with its own preference, it start approaching to the target. If two individuals of different sexes approached each other, they may have intercourse when the distance between them became short enough. After the intercourse for a constant time, their behaviors transit to the dazed mode to slowly move apart from each other, then start roaming again. The fertilized eggs incubate after some duration. The number of new born larvae is maximally 20 or less depending on the population density around the mother and the total population size in the current virtual world. The limitation of the number of individuals is to avoid a population explosion and to guarantee the smooth movement in the simulation.

Each individual has a numerical status value of energy that constantly decreases depending on the mode. When the energy level became low, it stops the current behavior to transit to the eating mode. After it ate enough, it returns back to the mode it was doing before eating. It would be more realistic if the growth and consumption of algae could also be modeled and simulated, but the current implementation assumes that algae is always available in enough amount to save shrimp from starvation. When an adult individual is roaming and it has no target of the partner, it may leave from the bottom and start swimming to move straight toward another place in a given probability. The transition from swimming to roaming is also determined in a given probability. The death is also determined in the same manner.

For the motion in any mode, each individual is affected by repulsion forces from the others surrounding it in order to avoid mutual collision, except the partner target as similar manner with classic

BOIDS model for collective behavior [7], though it employs forces of neither cohesion nor alignment with neighbors except the target partner. The male shrimp tends to approach the position on the target's back and to align the orientation. The female stays on the bottom and is not applied an alignment force to.

4. Model of Shapes

For the visualization in 3D space, the author designed the contour of bottom surface of the pool as shown in Figure 2, and the shapes of larva and adult shrimp in Figure 3.

In order to reduce the computation cost, the author also designed simplified shapes of both larva and adult. Because the load for scene rendering depends on the number of vectors necessary to be processed, such omission of some details is effective. The shape is drawn by the simplified version when it is small enough in the rendered image on the screen.

It could be better to make each individual move its legs, fins, and antennas, though these body parts are fixed in the current version.

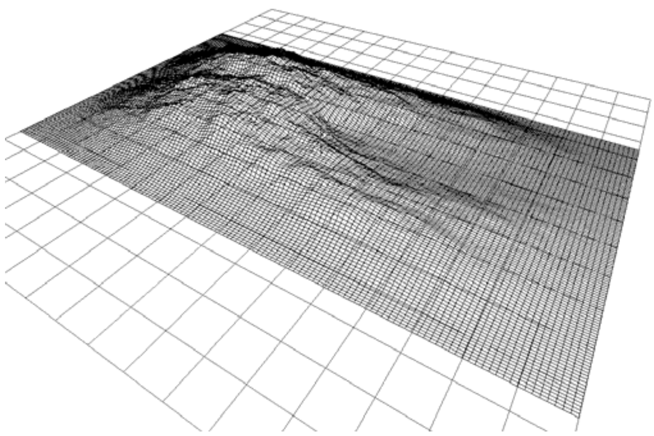

Fig 2. 3D model of contour for the bottom of the pool in the wireframe, made by a fractal random generation of natural landscape.

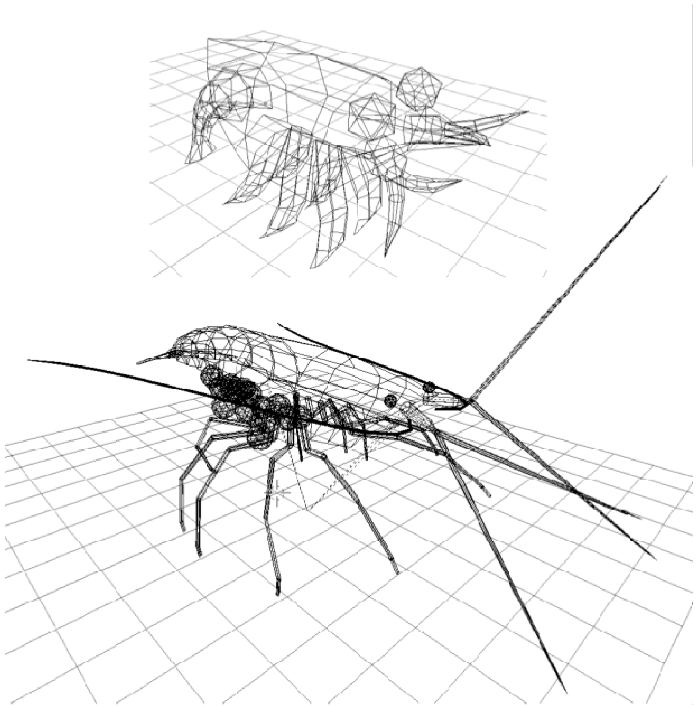

Fig 3. 3D model of larva and adult shrimp.

5. Viewpoint Control

Conceptually, this piece should display a scene to focus on the behavior of shrimp for reproduction to satisfy the motivation as described in section 1. It is also effective for visitors if they can observe not only the perspective view of the virtual pond but also the detail of individual behaviors and relations. To achieve this requirement, the author implemented a functionality to make the virtual camera move to explore in the pond. The home position of the camera is above water surface to provide a view of whole area of the pond. It moves smoothly toward the position and orientation where a sampled individual can be observed from upper position to look it down in 45 degree. The individual is randomly chosen from the list of lovers who has a partner target. After tracing the sample for 15 seconds, the camera moves again to a newly selected sample.

This motion of the virtual camera starts when the visitor covers the screen by their hands. It was easy to detect such visitors action by ceiling camera as the exhibition space is dark enough to measure how much portion of the screen is hidden behind obstacles above it. When the obstacles left, the virtual camera moves back to the home position slowly.

Figure 4 is an example of the snapshot captured when a sampled lover is closed up by the virtual camera. As shown in this image, a sign is attached to the monitored individual to show what it is doing.

Fig 4. A snapshot during the virtual camera is tracing a sampled individual.

6. Implementation and Installation

The software was written in Objective-C and developed using Xcode on macOS 10.14 utilizing 3D graphics framework named SceneKit provided by Apple [8]. This framework includes easy APIs to import 3D shapes from a file of a standard format. The author used Blender [9], an open source 3D modeler, to draw the necessary models described in section 4. The software runs on Mac mini 2018 equipped with Core i7 CPU under a supervised control by AppleScript that starts and stops the system to follow the exhibition schedule. The states of the population are saved into a file before it stops, and it is loaded just after the system starts in the morning of the next day, so that the evolutionary process continues throughout whole of 40 days of the exhibition. For both simulation and rendering under the condition that the maximum population size is limited to 500, the processing speed is faster than 30 frames per second, enough to be recognized as smooth motion.

Figure 5 is a photograph taken at the exhibition site of Volcana Brainstorm. A 55-inch Full HD monitor laid on the floor facing upward with ornaments made of some pieces of real volcano rocks, artificial grass, and cloths. This ornamentation was designed by Elena Knox. Sound effects were also attached in the software that bring an atmosphere under the water with a mixture of sampled sounds of bubbles and click noises.

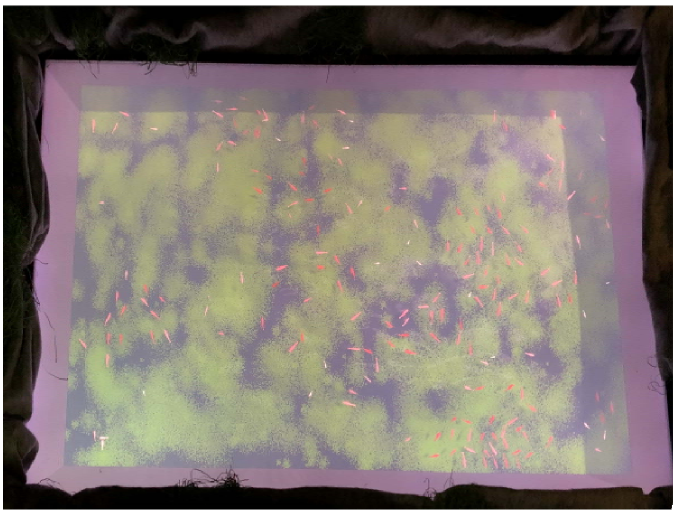

Fig 5. A photo of installation at the exhibition.

7. Concluding Remarks

A computer simulation of evolutionary ecosystem is one of the possible sources for a type of generative art. From a view point of artistic production, it is important not only how the mechanism behind the generative system works, but also how to visualize the complex phenomena produced through the generative process. It should have an explainable connection with the concept of the artwork. As described in section 5, this system uses a motion control of the virtual camera so as to provide the viewers a natural transition of scenes and closeups to show what the individuals are doing. The author designed the motion through several times of trials and error. He wishes to expect a raise of more scientific researches concerning the effective camera control for filming in the 3D space in both real and virtual world.

References

[1] E. Knox: Volcana Brainstorm, http://www.elenaknox.com/volcana.html

[2] Koganecho Bazaar 2019, http://koganecho.net/koganecho-bazaar-2019/

[3] Ecosphere, https://eco-sphere.com

[4] D. L. Henninger, T. O. Tri, N. J. C. Packham: NASA’s advanced life support systems human-rated test facility, Advances in Space Research, 18(1–2): 223-232, 1996.

[5] Halocaridina rubra, https://en.wikipedia.org/wiki/Halocaridina_rubra

[6] T. Unemi and D. Bisig: Rapid Biography in A Society of Evolutionary Lovers, Proceedings of the 20th Generative Art Conference, 431-441, Ravenna, Italy, December 2017.

[7] C. W. Reynolds: Flocks, herds, and schools: A distributed behavioral model. Computer Graphics, 21(4):25-34, 1987. (SIGGRAPH ’87 Conference Proceedings).

[8] Apple Co.: SceneKit, https://developer.apple.com/documentation/scenekit

[9] Blender, https://www.blender.org