**Brine Shrimp - Life cycle Simulation**

Submitted by

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**Abstract**

Brine shrimps, scientifically known as genus Artemia, are vastly found among highly saline water bodies around the world (En.wikipedia.org, 2019). Their life cycle consists of four different stages. This report explains the usage of brine shrimp life cycle simulation, to analyse the life of brine shrimps using digital simulation methods. This simulation includes all the four stages of its life cycle and their asexual reproduction. The life stages, reproduction methods are investigated during this project. The outcome is a 2-D simulation of brine shrimps, which can be improved further by adding certain parameters, which will provide a realistic simulation.

**Background**

Brine shrimps are known for their high saline tolerance. They are used to measure toxicity in liquids in laboratory scenarios. These brine shrimps are also sold as novelty toys with 'Sea Monkeys' or 'Sea Dragons' moniker (En.wikipedia.org, 2019). Noticing that these are sold as toys, the maintenance of these organisms could be assumed to be radically easy. Brine shrimps could reproduce both sexually and asexually. For this attempt, only the asexual reproduction will be simulated.

Brine shrimps begin their life in the form of eggs. These eggs, sometimes laid before the environment dries up, goes into a dormant state. When the environment is filled with water, the eggs come back to life. After the eggs are out of dormant state, within 24-36 hours they are hatched. These hatchlings then grow into juveniles. The juveniles can't reproduce as their sexual organs are not developed in this stage. When the juveniles turn into adults within 8 days of time, they start reproduction. The female adults have a sac at the bottom of their body stem to carry the eggs ("Brine Shrimp Life Cycle", 2019). These eggs are then released into the environment after the gestation period. Thus, the life cycle continues.

The initial idea of the program was to take in a number of time steps, which will simulate the program for the input number of times with a default number of shrimps in the exhibit. The exhibit size is predetermined to be 1000x500 units. The simulation will show the movement of the shrimps along with their growth and death. Asexual reproduction in males at regular intervals to denote gestation period, was planned. The different states (egg, hatchling, juvenile, and adult) would be denoted by different colours on the simulation graph.

**Methodology**

The methods devised to build the simulation are, command line arguments and parameter sweeps for executing the program, random number generation for the movement of the brine shrimps, scatterplot method to visualise the simulation, and lists for storing the shrimp data.

The program started with the baseline of collecting the positional values of the initial stages of shrimp life cycle. These positional values are then added to the Shrimp class where the movements are configured for different stages of the life cycle. This shrimp class then assigns the sizes for those life stages. A time to evolve from a stage to another is defined initially, which is compared with the current age of the shrimp, which is incremented with each time step. Comparing this time taken to evolve with the current age, provides the leeway to change the state of shrimp from one to another. The shrimp life cycle majorly consists of adult stage activities, hence the evolution time for the egg, hatchling, and juvenile stages are capped to two, keeping the overall life expectancy of sixteen.

The movement of the brine shrimp varies according to the life stage. Earlier stages of brine shrimp life cycle are slower than the adult stage. This is because of the fact that the limbs and body stem doesn’t grow fully until the adult stage resulting in slower movement. This movement is generated using random numbers, to make the movement in simulation feel real. The collision avoidance is executed by moving the shrimp in opposite direction, when the position of the shrimp is similar to the boundaries of the exhibit. All this data is pulled into the executed program by the class and are stored in different lists according to the life stage to be plotted separately.

The reproduction part of the program, when executed, checks life stage of the shrimp. If passed to be an adult, the program adds an egg into the exhibit after two simulation time units. Since the shrimp is not deleted from the exhibit, just changed into an egg state, the age of that individual unit remains the same. A workaround to reset the age of the individual, counts back the age from zero again. This asexual reproduction is simulated in a way that the egg laid after a gestation period (two simulation time units).

The different stages are life should look differentiated in order to simulate close to real. Hence the differences in size and life stage are visualised using different markers and colours using scatter plot method. The matplotlib library has the scatterplot method, which is easy and simple to be executed. A subplot is created in order to execute four different plots for the data with four different stages of brine shrimp life cycle. The egg stage of the brine shrimp denoted by red colour with a triangle marker shape. After it evolves into a hatchling, it is denoted by green colour and a ‘X’ marker. The juvenile stage is denoted by black colour with a square marker, and the adult stage is marker by circles of blue colour. The different colours and markers make it easy to identify the life stage of a shrimp at any point of the simulation. This also improves the understanding of brine shrimp life cycle events.

After the initial idea to execute the command with only the simulation time input, the simulation looked too repetitive for anyone who tries it more than twice. So, adding another parameter will improve the overall interaction with the simulation and give the power to execute in hands of user. The number of shrimp eggs to be released into the exhibit is added as an input parameter, so the user can try different scenarios. This is implemented using the command line parameter method learnt from the practical 6 of Fundamentals of Programming. The user has to input two parameters for number of shrimps and simulation time while executing the program file.

A parameter sweep method is also added to the program, in order to simulate the experiment multiple times. Here the parameter sweep file shrimp\_sweep.sh, checks in the input in the command line for inputs denoting the number of experiments and number of iterations. Multiple executions are useful to compare the results of the simulation. The data from the parameter sweep are saved to a new folder created for that particular simulation session. An image of the final simulation time step is also saved along.

**To Execute the Simulation**

Executing via command line arguments:

**python3 shrimpSimBase\_v2.py <Number of shrimps> <Simulation time>**

Example:

**python3 shrimpSimBase\_v2.py 5 10**

The above example will run a simulation with five shrimps for ten time-steps.

Executing via parameter sweep:

**sh shrimp\_sweep.sh <Number of Experiments> <Number of iterations>**

Example:

**sh shrimp\_sweep.sh 1 2**

The above example will run a parameter sweep with one experiment and two iterations. The simulation results and files will be added to a new folder that is created within the current directory.

**Results**

A simulation that runs for ten time-steps with five shrimps will give these results.

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In these results one can see all the four life stages of the brine shrimp, along with the asexual reproduction.

**Conclusion**

This brine shrimp simulation throws light on the life cycle of these organisms, where the user can learn about different stages of brine shrimp’s life, their movement, the ways of reproduction. Though this simulates the overall life cycle, this is still limited in the aspects of real-life, like collision avoidance among the individuals in the exhibit, sexual reproduction, better ways to visualise the looks of the brine shrimp, and a more flexible simulation interaction and input handling. This will be a task for the future, where the simulations look more realistic and approachable.

**References**

Brine Shrimp Life Cycle. (2019). Retrieved 30 October 2019, from https://learn.genetics.utah.edu/content/gsl/artemia/

Brine shrimp. (2019). Retrieved 30 October 2019, from https://en.wikipedia.org/wiki/Brine\_shrimp