High Performance Computing Programming Exercises

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Neutral Theory Simulations

Question 8

Figure 1 shows the system will always converge to a a state of minimum species richness of 1 in a community as time increases. This is because there is no speciation occurring within the community and when the last individual of a species dies, it is replaced by another individual belonging to a different species that is already present in the system as there is no input of new species into the system.

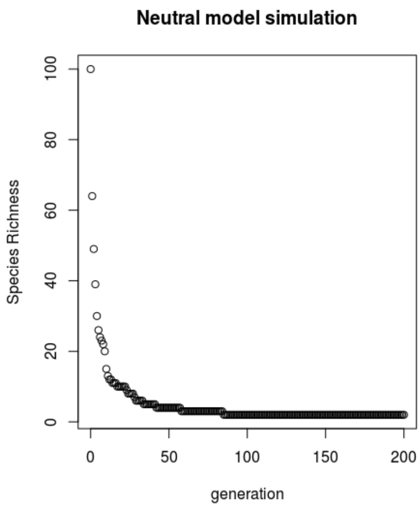

Figure 1: Neutral model simulation showing the state of a community's species richness as time progresses.

Question 12

Figure 2 shows that the initial maximum state converges towards a minimum state of species richness and eventually reaches a plateau when speciation is introduced into the system. The results show a rapid decline in species richness because a community with maximum species richness will result in many species with low populations sizes; these species are less stable and unlikely to survive for a long period of time and therefore become rapidly extinct.

Comparatively, the initial minimum state gradually converges towards a maximum state when speciation occurs at random but also reaches a plateau. The neutral model shows a gradual increase in species richness over time because speciation occurs at random and not every new species that is introduced to the system survives long enough to become stabilised and affect the overall state of the system.

A species has more of a chance of survival when more individuals of the same species are introduced to the system. This tells us that the initial states of the communities have little effect in determining species richness over generations of time.

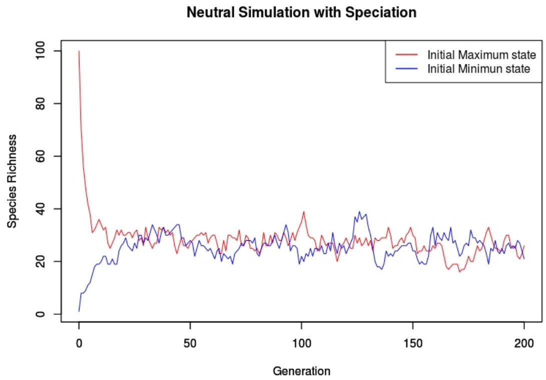

Figure 2: Neutral theory simulation with speciation showing species richness plotted against time.

Question 16

The bar plot in Figure 3 shows that the number of different species present in a community decreases as the average species abundance increases. The initial condition of the system doesn't matter because the average species abundance distribution is only recorded after the burn in generations, when the system has stabilised. The state of the community after the burn in period becomes the new initial state before the octaves are recorded.

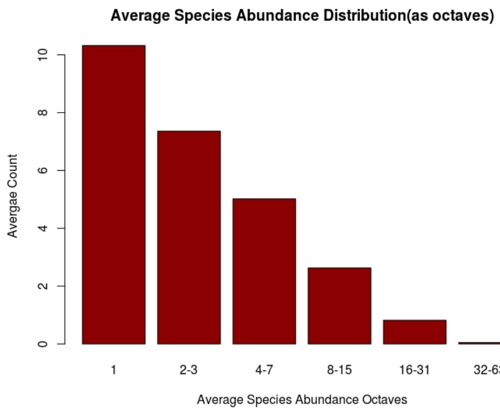

Figure 3: Bar plot showing the average species abundance distribution as octaves resulting from running neutral model simulation for 2000 generations.

Simulations using HPC

Question 20

	Species abundances octave sizes										
Community size	**1**	**2-3**	**4-7**	**8-15**	**16-31**	**32-63**	**64-127**	**128-255**	**256-511**	**512-1023**	**1024-2047**
500	3.07	2.54	2.29	2.13	1.99	1.77	1.41	0.839	0.181	-	-
1000	6.14	5.08	4.56	4.23	3.89	3.41	2.63	1.54	0.457	0.0212	-
2500	15.3	12.7	11.4	10.5	9.61	8.30	6.34	3.66	1.19	0.119	0.000753
5000	30.7	25.4	22.8	21.0	19.2	16.5	12.5	7.17	2.42	0.289	0.00512

Table 1: Average total octave results for four community sizes (to 3 sig.fig.)

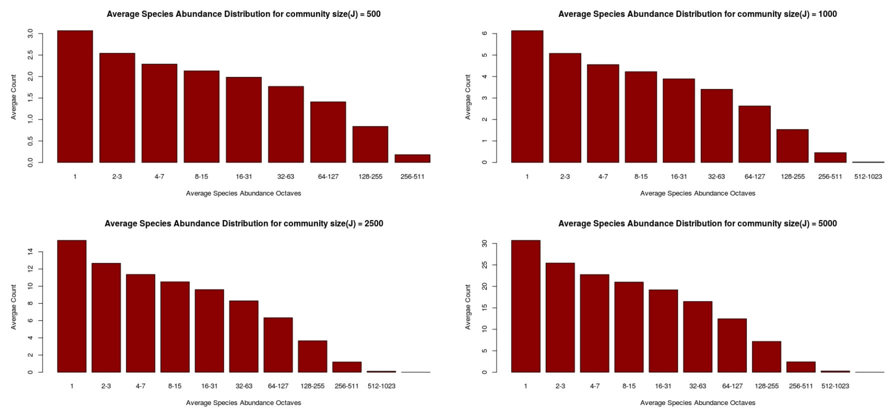

Figure 4: Bar plot showing the average species abundance distribution as octaves resulting from running neutral model simulation on four different community sizes.

Fractals in nature

Question 21

$$\int ize = width^D$$
$$log(size) = log(width^D)$$
$$log(size) = D.log(width)$$
$$Dimension(D) = log(size)/log(width)$$

Fractal dimensions are calculated as a ratio of the log of size divided by log of width of the fractal, where size is the number of units repeated in the fractal and width is the number of times the side is divided to fit the self similar units.

The first fractal image (Sierpinski carpet) has a width of 3 as a self similar unit fits within the original width of the fractal 3 times, and the size is 8 because the self similar pattern is repeated 8 times to give the overall fractal image. Therefore, the dimension can be calculated as:

$$\mathcal{D}imension = log(8)/log(3)$$
$$= 1.893$$

The second fractal, known as the 'Menger Sponge' has a width of 3 and a size of 20, as there are 20 repeated self similar units that make up the fractal shape. The dimension of this fractal object is:

$$\begin{aligned}\mathcal{D}imension &= log(20)/log(3) \\ &= 2.727\end{aligned}$$

Question 22

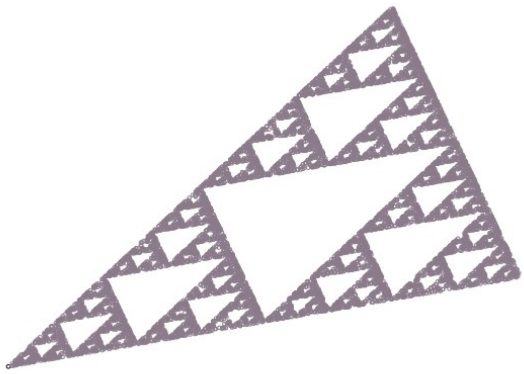

Figure 5: is a geometric construction produced by repeatedly performing steps which plot 3 points on a plane to form a triangle, finds the midpoint between two randomly selected points and repeats the process iteratively resulting in the fractal image.

Question 25

The function calls turtle and then itself iteratively, which infinitely draw lines at an angle of 45 degrees to the right of the previous line direction, with subsequent lines drawn getting shorter each time resulting in the spiral shape. This function will eventually crash as there is no limit set on the length of the line argument, thus causing the function to loop infinitely until the length of a line can no longer be divided any further.

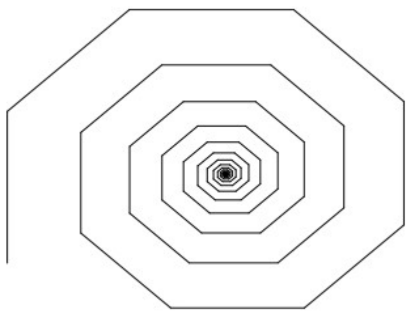

Figure 6: Plotted using an iterative function that draws a spiral.

Question 26

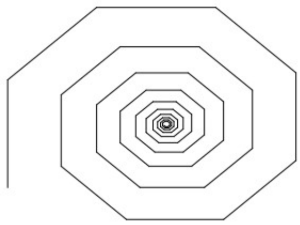

Figure 7: The spiral2 function draws a spiral using an iterative function and will only act if it's called with a line length above a certain size, this prevents it from calling the function recursively and crashing.

Question 27

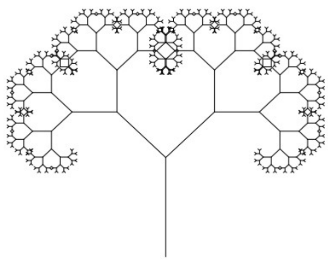

Figure 8: Line plot resembling a tree produced using the function tree.

Question 29

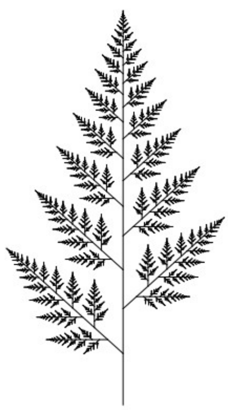

Figure 9: Line graph plotted to produce a fern structure using the fern2 function.