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CS 475 – Spring 2019
Project #3
Functional Decomposition

The data and graphs in this report analyze a grain growth simulation utilizing parallel sections with OpenMP. My program was developed on macOS Mojave version 10.14 and tested on the flip server provided by Oregon State University. No testing was done on macOS since OpenMP isn't supported.

This program sections off different tasks in the code and assigns them each to one thread. Each function within each task will be responsible for taking a current value from a global variable and preparing to update it through each step in time (a month in this simulation). Also, since we'll be utilizing OpenMP sections, synchronization will be a major component in this program working correctly. Global variables present the risk of one function modifying a value before another can use the initial value, leading to an incorrect calculation. Therefore, I'll be using barriers to force threads to wait for all others to finish their calculations before modifying a global variable. Then those functions will wait for the Watcher() function to update environment variables and print out all necessary data before continuing to the next iteration.

My Agent Function and Variables

Grain typically grows best within a certain range of temperatures and precipitation levels. However, when conditions get too harsh—too hot and dry, too cold and wet, subfreezing, etc.—it can be detrimental to grain growth. Therefore, my variable will monitor and amplify the adverse effects of any weather condition that can significantly change this growth.

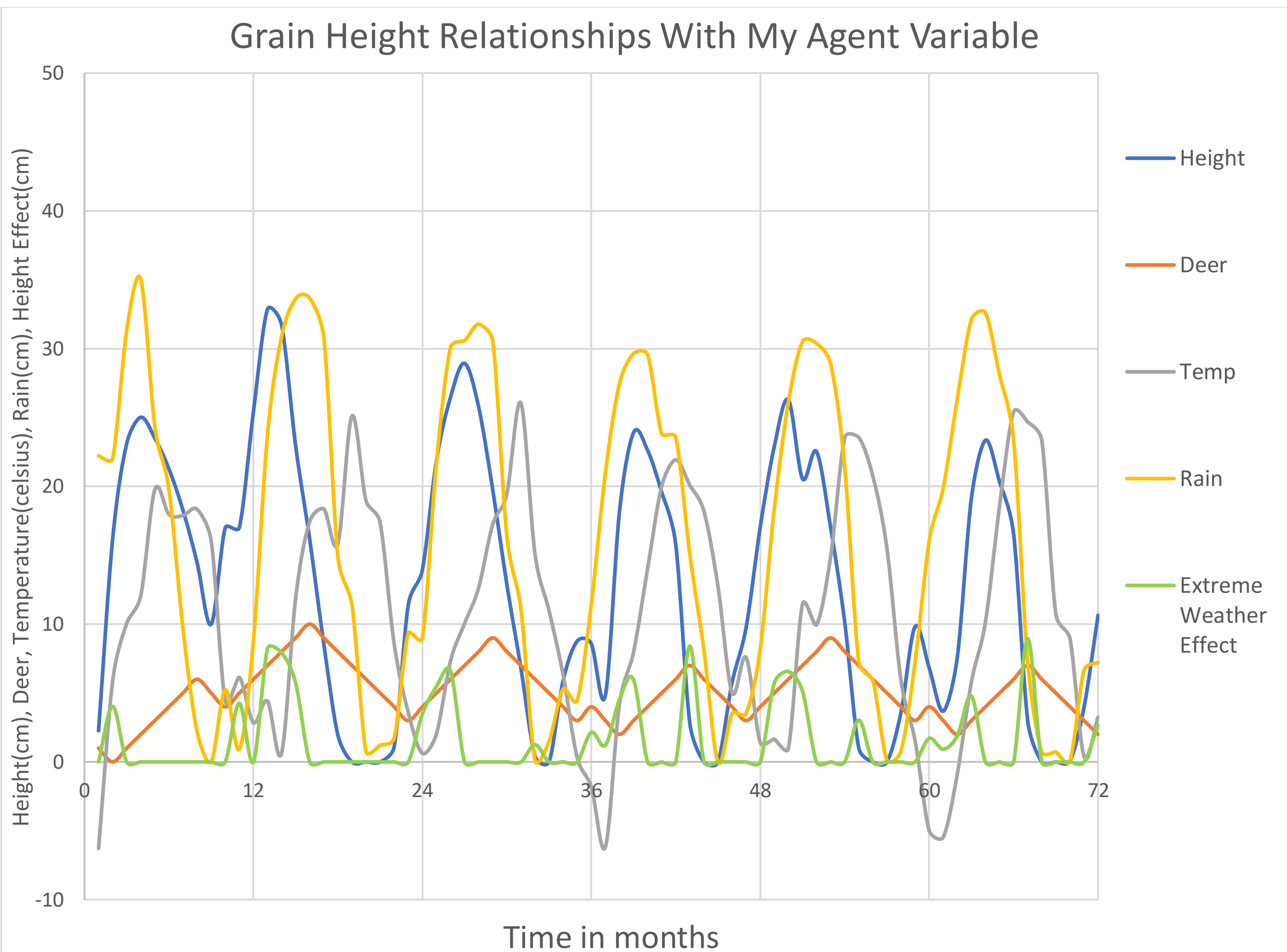
My agent function is called **ExtremeWeather()** and my two agent variables are called **NowExtremeWeatherEffect** and **NowHeightEffect.** The **NowExtremeWeatherEffect** variable is a multiplier that will be determined within the **ExtremeWeather()** function. The **NowHeightEffect** is measured in inches and is calculated by the **Grain()** function. It is my own-choice agent variable that will be graphed along with all the other variables. **Grain()** will calculate it as follows:

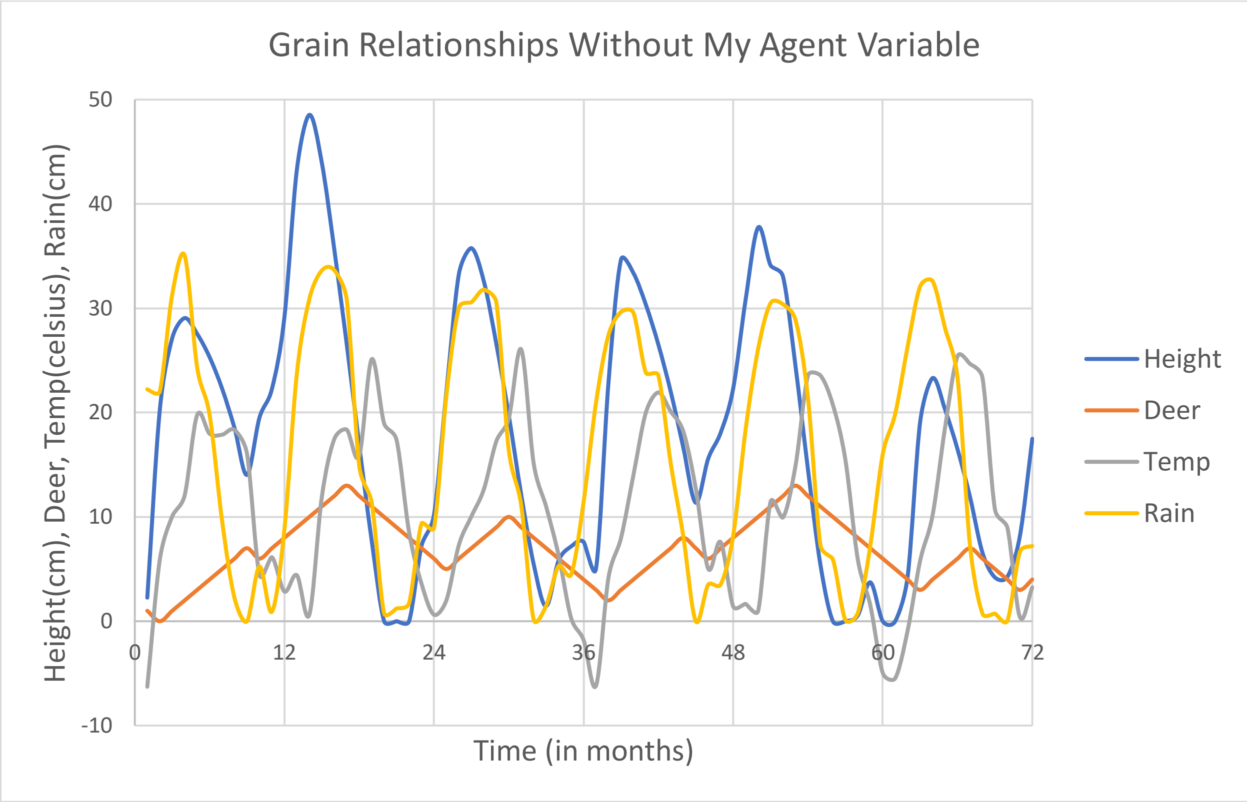
NowHeightEffect = height – (height * NowExtremeWeatherEffect)

It represents the change in height (in inches) caused by any extreme weather. Extreme weather conditions will be determined and quantified by the **ExtremeWeather()** function. It will monitor the current temperature and precipitation levels to determine any conditions that are detrimental to grain growth. For example, if the temperature is hot with low rainfall, a field fire will trigger. The function will set the multiplier accordingly and assign it to the global variable **NowExtremeWeatherEffect.** There are also several tiers of intensely cold weather that have lower and lower multipliers. In other words, the harsher the weather the lower the multiplier. Additionally, the height becomes the initial height multiplied by the multiplier (which is a value between 0 and 1), thus decreasing its final value. The equation shows that the lower the multiplier, the larger the adverse effect on grain height. Furthermore, even though my variable only directly effects grain height, it also indirectly effects graindeer population since it is controlled by grain.

Graphs

Below are the graphs and raw data of two simulations. The first graph is the simulation that includes my agent function, agent variables and a fourth thread. The second graph is of the same simulation excluding my function and variables. It has been included as a comparison to show the differences caused by my agent function and variables.





At a quick glance the two graphs almost look the exact same. However, upon closer inspection, it is obvious that both grain height and deer population are lower as a result of my agent variable being in the simulation. For example, grain height peaks around the 13- or 14-month region in both graphs. Although, in the first graph that includes my function and variables, the peak is only about 33 centimeters. The peak in the second graph is closer to 50 centimeters. Much of this difference can be attributed to my Height Effect variable, which is at one of its largest values in that same region. This was caused by the extreme cold temperatures at the time, which can be seen by looking at the temperature line directly below. There are several instances of this same scenario in the first graph. By looking at the green line for "Height Effect", you can see that all of its peak values occur at times of harsh weather (either very cold or hot and dry) and large grain heights. This makes sense considering the equation above. Also, you can see that each of the peak values in the first graph are significantly lower than the corresponding peaks in the second graph. These are all examples of where my variable largely effected the simulation.

Additionally, the deer population is lower on average in the first graph. This is also intuitive considering the deer are controlled by the grain heights. Since my agent function and variables had large negative effects on grain, they also had adverse effects on deer. In the first graph the deer population never breaks ten whereas it does this twice in the second graph. The decrease in grain peak heights also forced the deer population to be more stable in the first graph. In other words, the range in deer population was significantly smaller in the simulation with my variable. It is safe to say that the reduction in fluctuation of grain height created a similar phenomon among the deer population. Furthermore, they tend to have a negative correlation with each other. Grain height seems to prosper as the deer population declines and dwindles as deer become more prevalent.

It is also noteworthy to mention that grain height and precipitation levels are largely positively correlated. Grain height seems to be on about a 1-month lag behind rain, but as rain increases it is quick to follow. The opposite is true of grain height and temperature. Typically, as the temperature line increases to hotter and hotter temperatures, grain height suffers. Temperatures tend to increase after grain height does (about a 2-month lag), so grain height eventually starts to decline when these temperatures reach a certain level. This implies grain does better at more moderate temperatures.

Raw Data Without My Variable

Month	Height	Deer	Temp	Rain
1	2.26	1	-6.28	22.23
2	20.2	0	5.86	22.02
3	27.15	1	10.05	31.33
4	29.06	2	12.07	35.04
5	27.55	3	19.77	24.33
6	25.31	4	17.97	19.78
7	22.3	5	17.88	9.62
8	18.51	6	18.34	2.21
9	14.03	7	16.05	0
10	19.52	6	4.44	5.24
11	22.27	7	6.13	0.92
12	29.14	8	2.85	8.8
13	43.28	9	4.41	23.74
14	48.54	10	0.64	30.88
15	43.96	11	11.89	33.62
16	35.65	12	17.46	33.65
17	26.55	13	18.36	30.82
18	16.9	12	15.84	14.9
19	7.75	11	25.11	11.39
20	0	10	18.96	0.76
21	0	9	17.36	1.22
22	0	8	8.56	1.73
23	7.23	7	3.59	9.37
24	10.2	6	0.62	8.94
25	22.09	5	2.03	21.7
26	33.3	6	7.32	30.08
27	35.76	7	10.05	30.58

28	32.58	8	12.65	31.78
29	26.58	9	17.25	30.56
30	19.74	10	19.45	16.4
31	12.12	9	26.05	11.1
32	5.45	8	15.1	0.15
33	1.45	7	10.98	1.49
34	5.83	6	6.31	5.3
35	7.17	5	0.31	4.47
36	7.61	4	-1.8	11.43
37	5.07	3	-6.17	20.97
38	22.94	2	4.21	27.44
39	34.65	3	7.96	29.64
40	33.37	4	14.02	29.56
41	30.33	5	20.01	23.82
42	26.52	6	21.93	23.55
43	21.96	7	20.09	15.06
44	16.65	8	18.2	8.14
45	11.36	7	12.73	0
46	15.59	6	5.03	3.51
47	18.08	7	7.57	3.53
48	22.3	8	1.42	8.2
49	30.84	9	1.66	18.39
50	37.74	10	0.98	26.09
51	34.12	11	11.44	30.49
52	33.03	12	9.96	30.38
53	24.47	13	14.89	28.89
54	14.56	12	23.55	21.41
55	5.42	11	23.56	7.29
56	0	10	20.74	5.92
57	0	9	15.5	0.13
58	0.56	8	5.91	0.8
59	3.73	7	1.54	7.23
60	0	6	-4.96	16.01
61	0	5	-5.47	19.88
62	4.3	4	-0.88	26.36
63	19.1	3	5.8	32.1
64	23.31	4	10.17	32.6
65	20.29	5	18.58	28.08
66	16.48	6	25.4	23.34
67	11.91	7	24.67	7.26

68	6.57	6	23.34	0.73
69	4.2	5	10.73	0.72
70	4.26	4	8.96	0.06
71	8.16	3	0.4	6.64
72	17.49	4	3.25	7.21

Raw Data with My Variable

Month	Height	Deer	Temp	Rain	Height Effect
1	2.26	1	-6.28	22.23	0
2	16.16	0	5.86	22.02	4.04
3	23.11	1	10.05	31.33	0
4	25.02	2	12.07	35.04	0
5	23.5	3	19.77	24.33	0
6	21.27	4	17.97	19.78	0
7	18.26	5	17.88	9.62	0
8	14.47	6	18.34	2.21	0
9	9.99	5	16.05	0	0
10	17	4	4.44	5.24	0
11	17.02	5	6.13	0.92	4.25
12	25.42	6	2.85	8.8	0
13	32.86	7	4.41	23.74	8.22
14	31.72	8	0.64	30.88	7.93
15	22.93	9	11.89	33.62	5.73
16	16.15	10	17.46	33.65	0
17	8.56	9	18.36	30.82	0
18	1.96	8	15.84	14.9	0
19	0	7	25.11	11.39	0
20	0	6	18.96	0.76	0
21	0	5	17.36	1.22	0
22	1.11	4	8.56	1.73	0
23	11.39	3	3.59	9.37	0
24	13.93	4	0.62	8.94	3.48
25	21.87	5	2.03	21.7	5.47
26	26.47	6	7.32	30.08	6.62
27	28.93	7	10.05	30.58	0
28	25.75	8	12.65	31.78	0
29	19.75	9	17.25	30.56	0
30	12.9	8	19.45	16.4	0
31	6.81	7	26.05	11.1	0

32	0.42	6	15.1	0.15	1.25
33	0	5	10.98	1.49	0
34	5.9	4	6.31	5.3	0
35	8.77	3	0.31	4.47	0
36	8.58	4	-1.8	11.43	2.15
37	4.84	3	-6.17	20.97	1.21
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45	0	5	12.73	0	0
46	5.75	4	5.03	3.51	0
47	9.77	3	7.57	3.53	0
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55	1.01	7	23.56	7.29	3.04
56	0	6	20.74	5.92	0
57	0	5	15.5	0.13	0
58	3.61	4	5.91	0.8	0
59	9.82	3	1.54	7.23	0
60	6.84	4	-4.96	16.01	1.71
61	3.68	3	-5.47	19.88	0.92
62	7.6	2	-0.88	26.36	1.9
63	19.14	3	5.8	32.1	4.78
64	23.35	4	10.17	32.6	0
65	20.33	5	18.58	28.08	0
66	16.52	6	25.4	23.34	0
67	2.99	7	24.67	7.26	8.96
68	0	6	23.34	0.73	0
69	0	5	10.73	0.72	0
70	0.07	4	8.96	0.06	0
71	3.96	3	0.4	6.64	0

72	10.64	2	3.25	7.21	2.66