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CS 420

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Project 1: “Edge of Chaos” in 1D Cellular Automata

Introduction

The purpose of this project was to allow the students to observe the “Edge of Chaos” phenomenon, also known as Wolfram class IV behavior. A given program allows the students to observe the differences in complexity between different models displayed in a visual format. My own work consists of 40 separate models, as well as a number of ways of visualizing the differences between them.

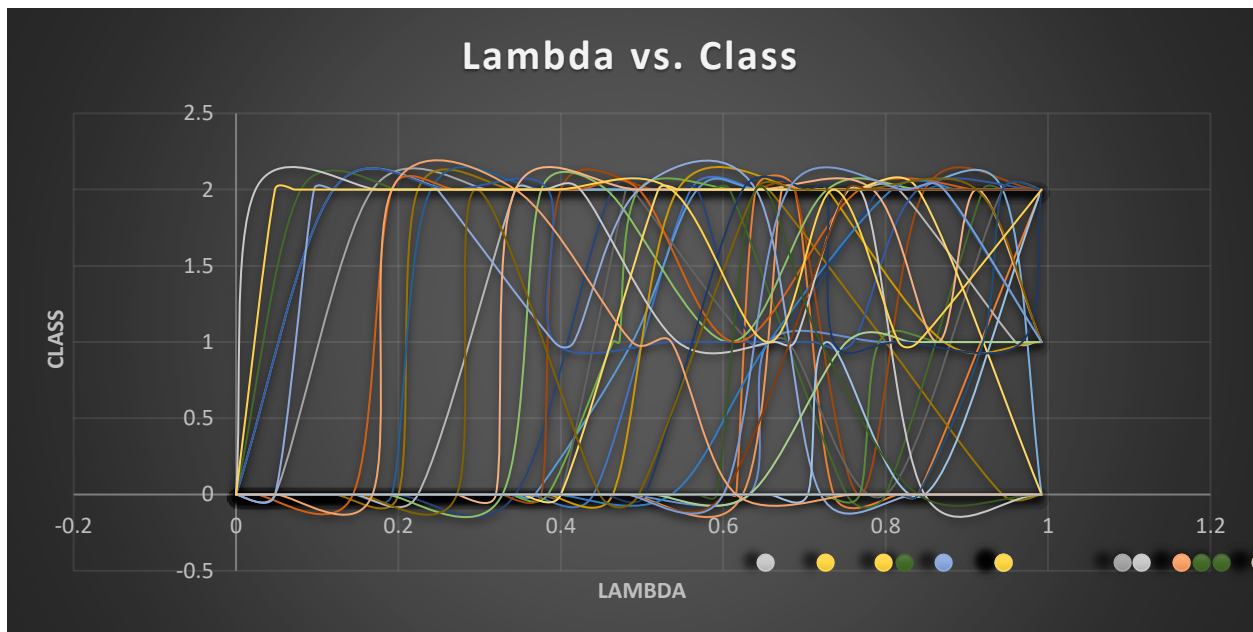
Calculations

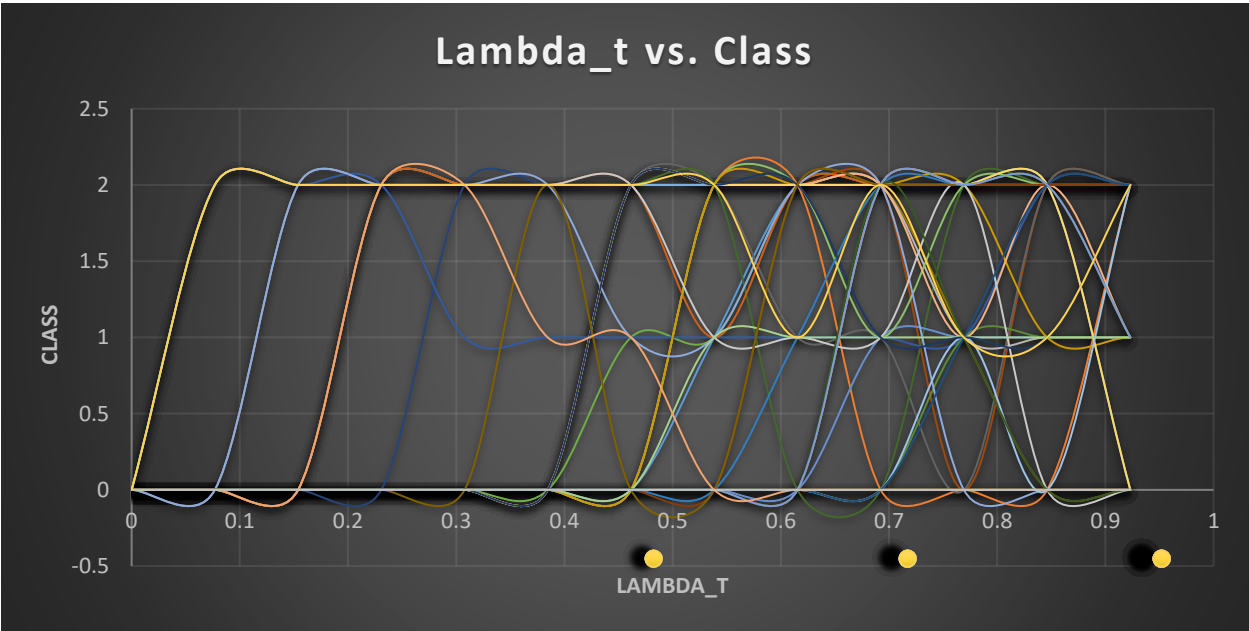
Over the course of my analysis, I identified 56 separate steps that qualified, to my eye, as class IV. I compiled these steps into a single list, and calculated the averages and standard deviation for their lambdas, lambda_ts, Hs, and H_ts.

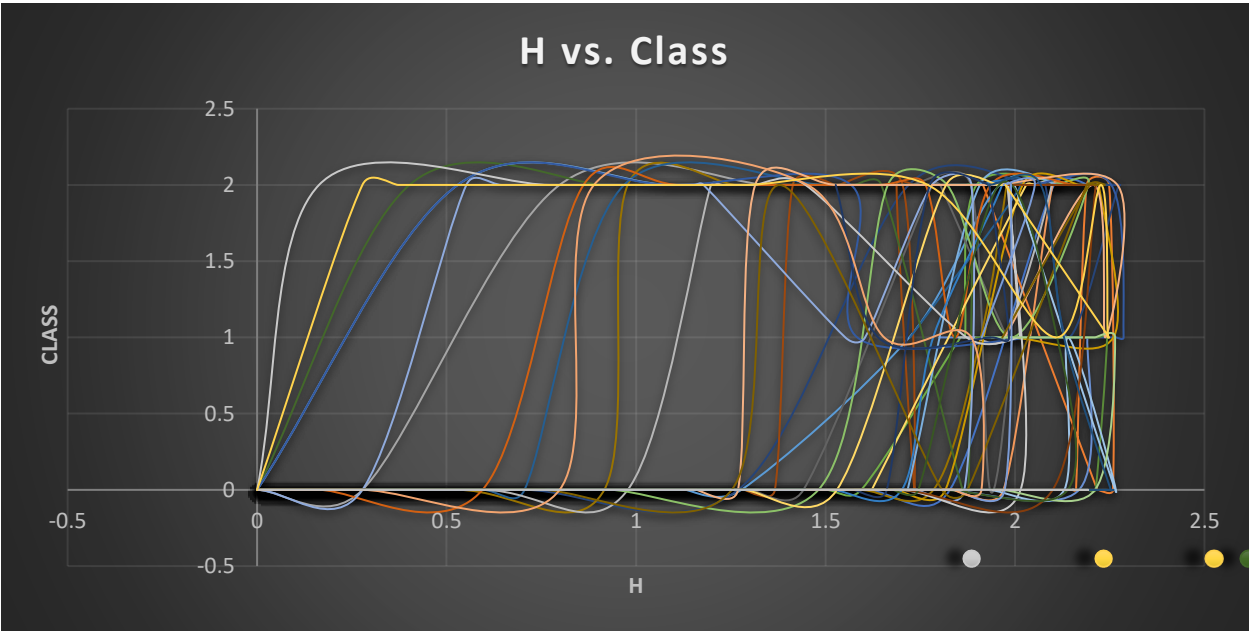
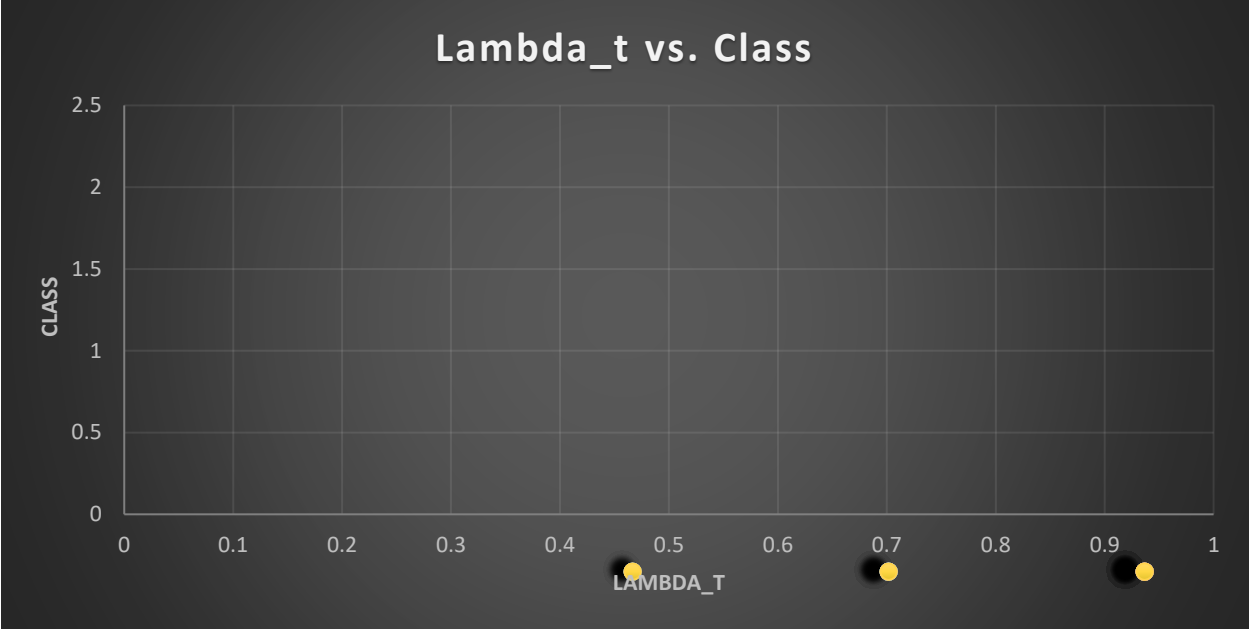
	Lambda	Lambda_t	H	H_t
average:	0.753571	0.700549	2.001073	2.072045
stdev:	0.182488	0.164445	0.197244	0.191801

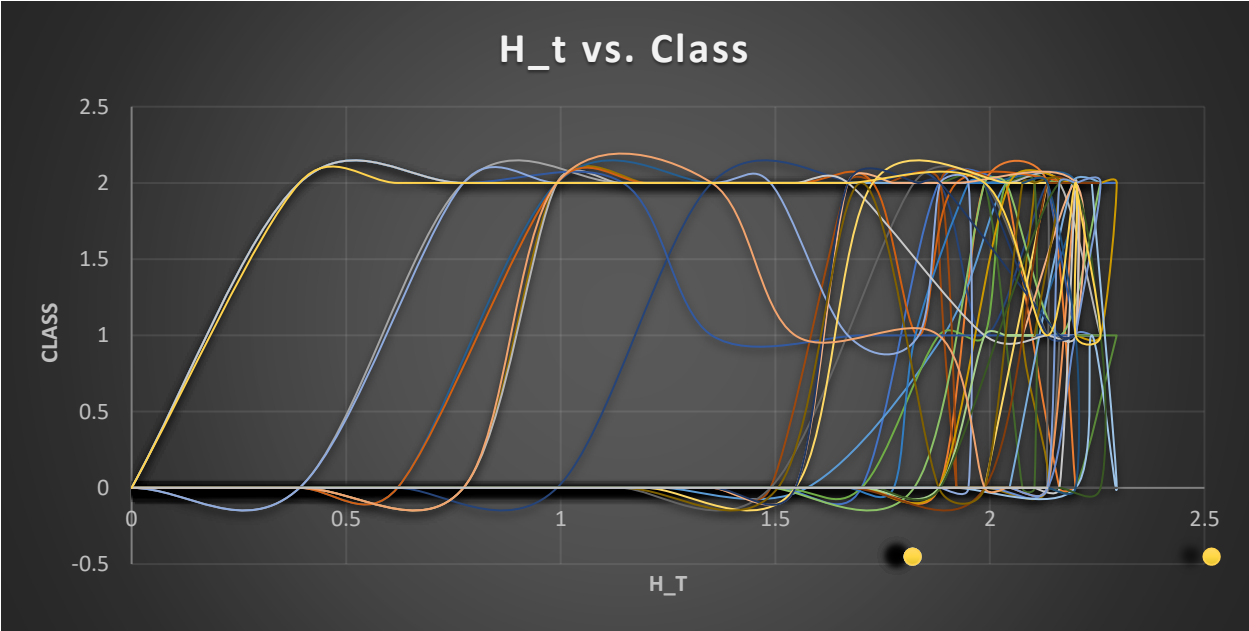
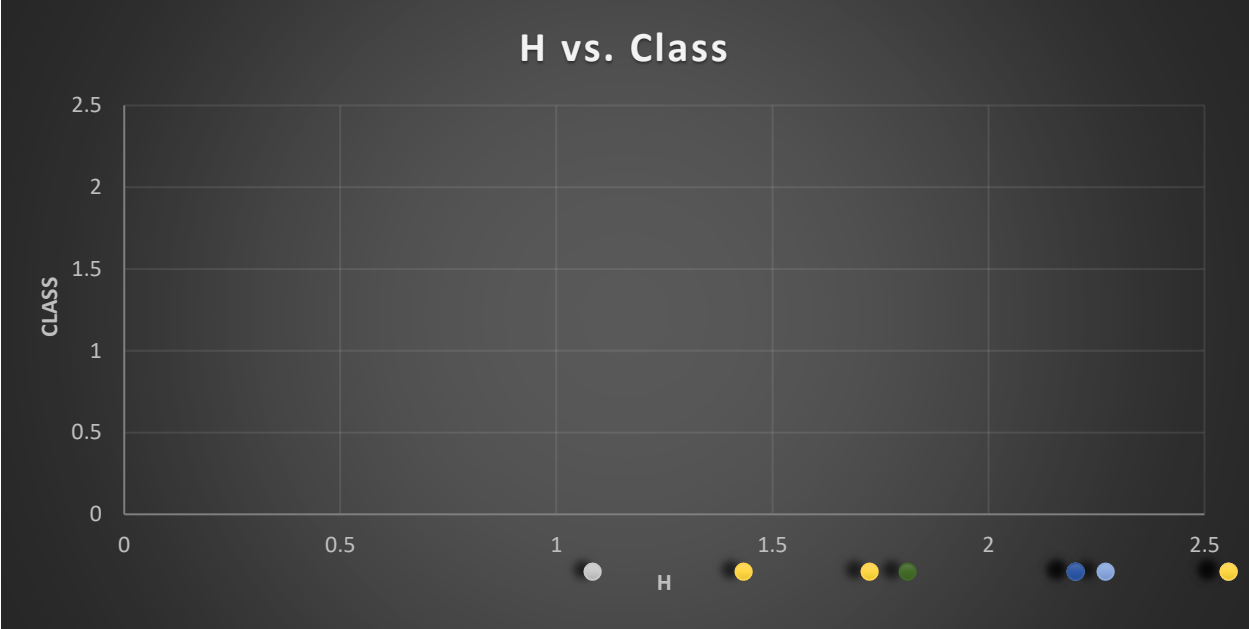
On first glance, it becomes very obvious that there is not much difference between the variables of the same name set (λ and λ_t). Then, it becomes clear that there is much more variation in the λ s than there is within the H set, based on their standard deviation values relative to the average value. In the λ s, the standard deviation represents a higher percentage of its average value than is seen in the H value. This indicates that the H values are more indicative of whether or not a step exhibits class IV characteristics. Now, of the H values, there is not enough difference in them to clearly say one is more indicative than the other. That being said, H_t does look to be slightly more of an indicator.

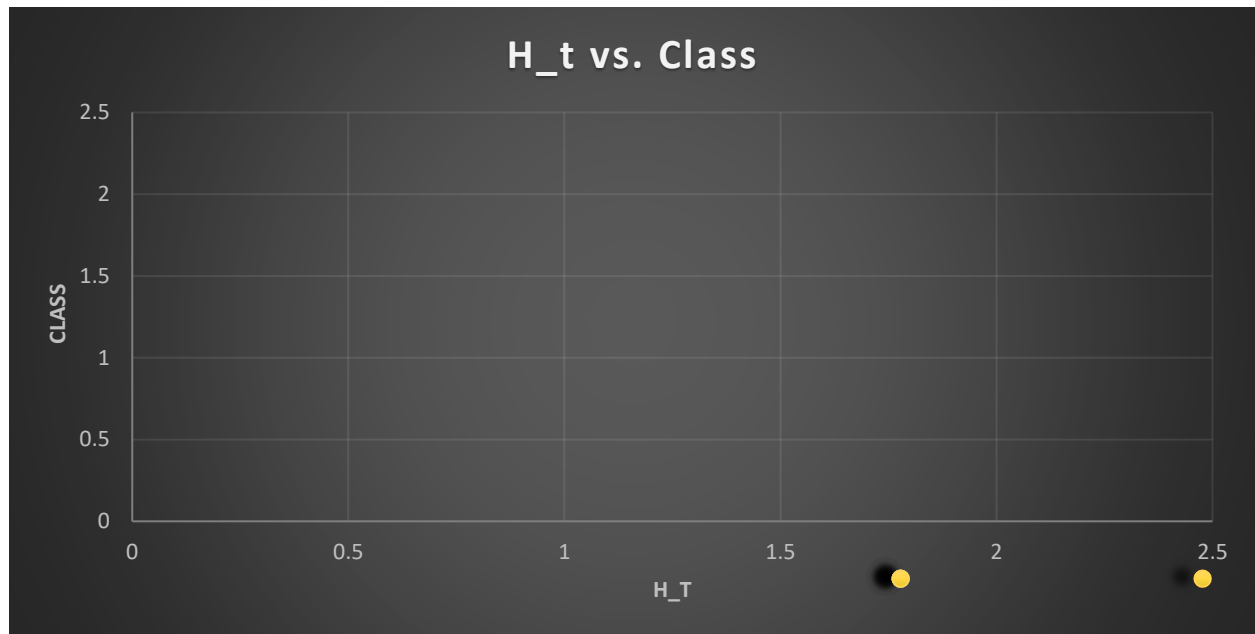
Graphs











As an addendum, I wanted to point out how the λ_t graphs differ from the others. For some reason, the values are all almost evenly spaced out along the x axis.

Discussion

While I suppose it is hard to say whether or not something is for sure an anomaly due to its own merits rather than my own possible misclassification, I am still confident in saying that while the λ , λ_T , H , and H_T values are quite indicative of whether or not a step is class IV or not, it by no means guarantees a step to be class IV. Looking at my class IV data, it is apparent that each step's λ , λ_T , H , and H_T is above a certain threshold, that which is much higher than would be expected from a class I or II. That being said, I do have a not so insignificant number of steps with high λ , λ_T , H , and H_T values that are not classified as class IV. One explanation to this is one that I hinted at earlier, that being that it may be due to human error. My own eyes and pattern recognition that I hold within my own brain might not be able to distinguish the classifications

with an accuracy that might be desired from this lab. Of course, this is not a conclusion that I would want to believe, as it points to me being fallible. The other option that I can think of would indicate that the λ , λT , H , and $H T$ values are in fact very similar to the concept of entropy, as may have been hinted at in the write up. An increase in entropy raises the number of options, or states, toward which a model may progress. While more options point to a higher probability of creating a complex structure, this would not preclude the creation of a simpler model. Simple things can still be created from complex phenomena.

Class IV Data

Step	Entry Zeroed	Class	Lambda	Lambda_t	H	H_t	Zeta	Observations
5	3	1	0.488	0.538462	1.720842	1.891995	0	irregular holes
5	1	1	0.472	0.538462	1.867822	1.987773	0	very large holes
6	12	1	0.464	0.461538	1.856297	1.881095	0	large holes
5	5	1	0.648	0.538462	2.140833	1.987773	0	irregular
3	4	1	0.68	0.692308	1.993208	2.161978	0	irregular
4	10	1	0.632	0.615385	1.978924	2.133938	0	irregular
2	5	1	0.8	0.769231	1.90932	2.075869	0	irregular
0	-	1	0.992	0.923077	1.723393	2.10391	0	irregular
0	-	1	0.992	0.923077	1.800211	2.10391	0	irregular

1	2	1	0.944	0.846154	1.934987	2.199688	0	irregular
2	7	1	0.8	0.769231	2.190993	2.237397	0	irregular
3	5	1	0.656	0.692308	2.190993	2.199688	0	irregular
0	-	1	0.992	0.923077	1.851151	2.133938	0	irregular
1	12	1	0.984	0.846154	1.893048	2.257756	0	irregular
2	1	1	0.96	0.769231	1.973389	2.257756	0	irregular
3	4	1	0.608	0.692308	1.990194	2.161978	0	irregular
2	3	1	0.76	0.769231	2.286629	2.199688	0	irregular
3	2	1	0.712	0.692308	2.267332	2.199688	0	irregular
4	11	1	0.688	0.615385	2.2464	2.133938	0	irregular
5	9	1	0.608	0.538462	2.154424	1.987773	0	irregular
6	1	1	0.584	0.461538	2.13075	1.881095	0	irregular
7	10	1	0.536	0.384615	2.063873	1.70044	0	irregular
8	7	1	0.392	0.307692	1.583706	1.35203	0	irregular
5	6	1	0.616	0.538462	1.842054	1.833927	0	irregular
0	-	1	0.992	0.923077	1.981811	2.199688	0	irregular
1	4	1	0.872	0.846154	2.259598	2.257756	0	irregular
4	6	1	0.656	0.615385	1.784027	1.826245	0	irregular
0	-	1	0.992	0.923077	1.896604	2.199688	0	irregular
1	4	1	0.872	0.846154	2.217872	2.295466	0	irregular
2	3	1	0.792	0.769231	2.242912	2.295466	0	irregular
5	3	1	0.416	0.538462	1.60439	1.833927	0	irregular
6	11	1	0.392	0.461538	1.55215	1.66918	0	irregular

0	-	1	0.992	0.923077	1.972826	2.075869	0	irregular
2	2	1	0.864	0.769231	2.237947	2.199688	0	irregular
3	3	1	0.688	0.692308	2.013183	2.199688	0	irregular
4	11	1	0.664	0.615385	2.011429	2.133938	0	irregular
5	8	1	0.544	0.538462	1.872277	1.987773	0	irregular
2	8	1	0.728	0.769231	2.140014	2.237397	0	irregular
0	-	1	0.992	0.923077	1.938109	2.03816	0	irregular
1	3	1	0.912	0.846154	2.115046	2.03816	0	irregular
2	12	1	0.904	0.769231	2.123778	2.075869	0	irregular
3	2	1	0.856	0.692308	2.206177	2.10391	0	irregular
4	11	1	0.832	0.615385	2.211141	2.03816	0	irregular
5	9	1	0.752	0.538462	2.264142	1.987773	0	irregular
1	11	1	0.968	0.846154	1.63901	2.133938	0	irregular
2	6	1	0.816	0.769231	1.939733	2.199688	0	irregular
3	3	1	0.736	0.692308	1.98408	2.161978	0	irregular
0	-	1	0.992	0.923077	1.966532	2.10391	0	irregular
2	11	1	0.92	0.769231	2.129417	2.199688	0	irregular
2	4	1	0.72	0.769231	2.110995	2.257756	0	irregular
0	-	1	0.992	0.923077	1.912271	2.199688	0	irregular
6	9	1	0.536	0.461538	1.884543	1.881095	0	wow, irregular
7	10	1	0.488	0.384615	1.654725	1.546594	0	irregular
1	6	1	0.84	0.846154	2.248269	2.257756	0	irregular

2	11	1	0.816	0.769231	2.244883	2.199688	0	irregular
4	3	1	0.656	0.615385	2.1094	2.133938	0	irregular