

COSC 420: BIOLOGICALLY-INSPIRED COMPUTATION
PROJECT 1 - “EDGE OF CHAOS”

CLARA NGUYEN

SYNOPSIS

This project involves exploring the “Edge of Chaos” phenomena in 1D cellular automata. We generate images via a CA simulator, and then try to identify and analyze different classifications based on how the simulators generate the patterns.

SIMULATION PROCEDURE

We had the choice of three simulators. Each had their advantages. Here are two of them:

1. **NetLogo version:** Allows for complete control over the generation. You can specify the seed, radius, and other variables entirely from within the application itself.
2. **Dr. Van Hornweder’s Java Program:** Completely automates a majority of the assignment for you, and is open source. Allows users to quickly generate X number of simulations in Y number of steps in a single command.

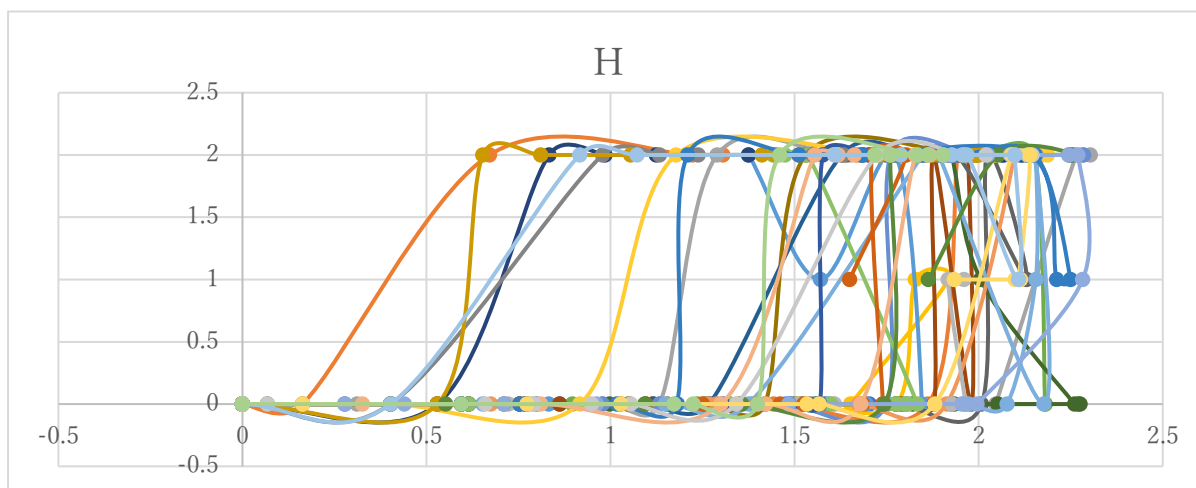
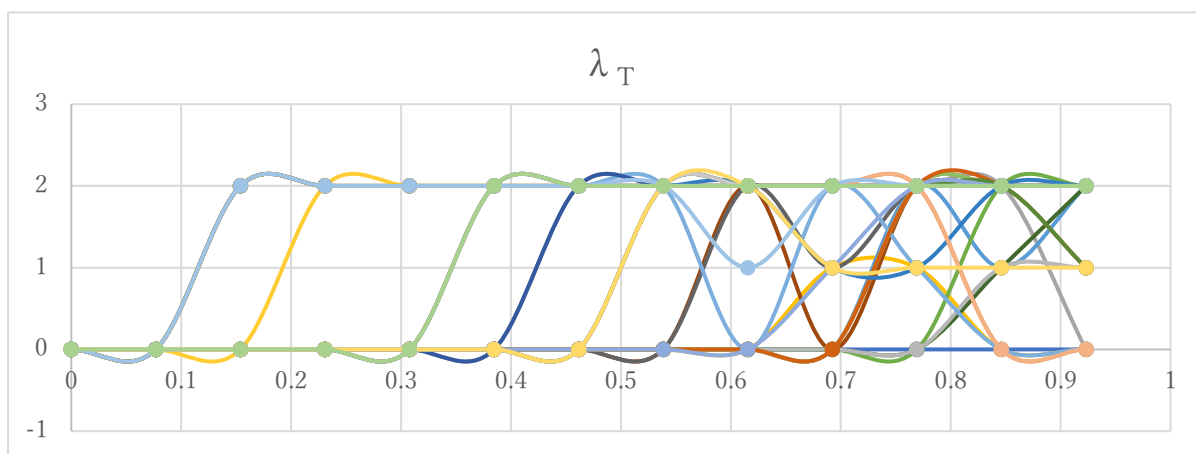
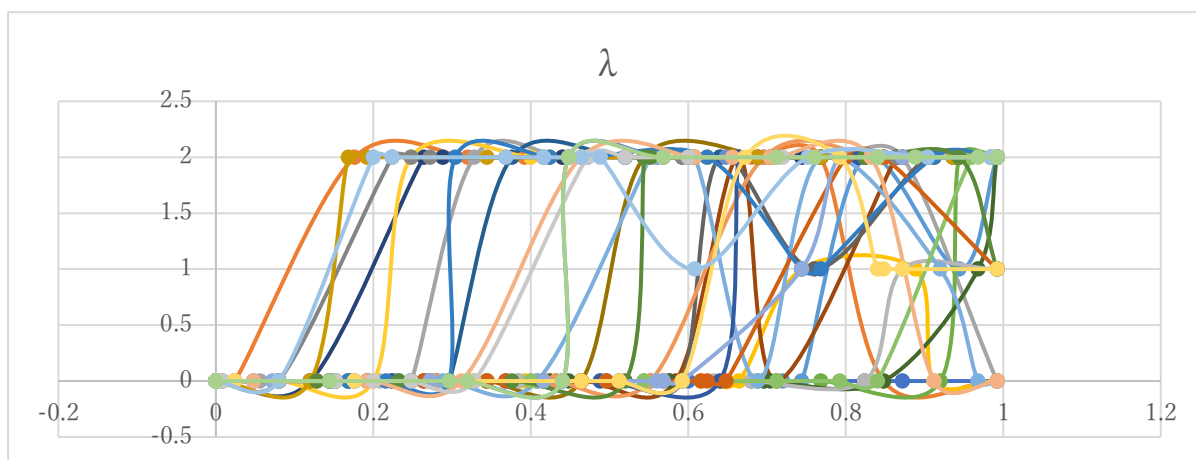
I chose the Java program for my analysis and identification. However, the tool generated several HTML pages along with the CSV of the computations done. Because the process of identification needed to be done quickly, I wrote up a quick shell script named “concat.sh”, which combines multiple of these generated HTML files together in to a single web page:

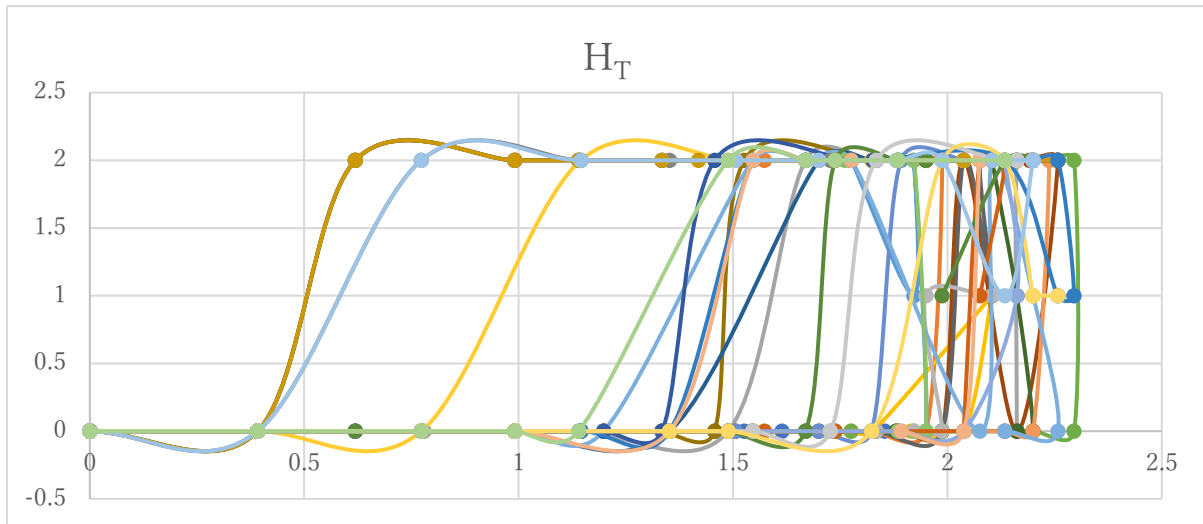
```
#!/bin/bash
# HTML Header
printf "<html><body>\n"
# Body
for F in $(ls -l *.html | sort -V); do
    cat "${F}" | sed \
        -e 's/^<html>.*$//' \
        -e 's/<body> //' \
        -e 's/^(.*)</body></html>$/\1/'
done
# Closing tags
printf "</body></html>\n"
```

Having this script allowed me to place the experiments side-by-side with the generated CSV file easily by simply having Chrome and Excel opened side-by-side.

GRAPHS

Here are the four graphs for λ , λ_T , H , and H_T . They involved **30** tests (as opposed to 20).

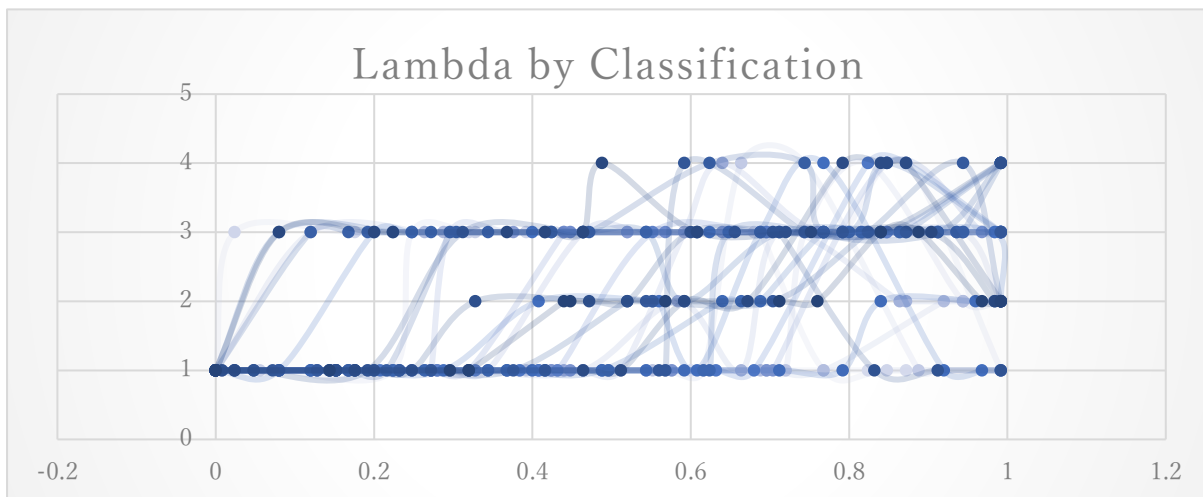




GRAPH ANALYSIS

The trending of the graphs tends to show a pattern that depends on the classification of the data.

There is actually another graph that we can use to show a particular pattern in the data.



The graph above is formatted in a way so that grouped instances are a darker blue, as opposed to uncommon instances, which are a lighter blue. We can see a clear pattern in this data, where the Lambda can help determine the type of classification the image is. Areas where the λ is below 0.75, the classification is guaranteed (from the data we have) to be Class I. Class I, on average, has a λ between 0 and 0.5. Class II, on average, has a λ between 0.5 and 0.65. There are also a few instances where λ is almost at 1 and it is Class II. Class III spans the entire spectrum, but most of its λ values reside between 0.6 and 0.9. Class IV has a λ generally above 0.5. Most of the Class IV values are above 0.7.

CALCULATIONS & CONCLUSION

As specified by the lab writeup, we must compute the average and standard deviation of the λ , λ_T , H , H_T values are for Class IV behaviour. Here is are the averages and standard deviations:

	Average	Standard Deviation
λ	0.817	0.139311
λ_T	0.762821	0.121978
H	2.001198	0.164886
H_T	2.109803	0.110604

However, I argue that this data may not be enough to come to a conclusion. So here's the computations for the averages and standard deviations of every class categorization, including the number of instances where a step was a specific classification:

AVERAGES

	Class I	Class II	Class III	Class IV
λ	0.380025	0.755238	0.623158	0.817
λ_T	0.353559	0.672161	0.575477	0.762821
H	1.196286	1.772562	1.72408	2.001198
H_T	1.244978	1.882132	1.782833	2.109803
# Cases	161	42	133	24

STANDARD DEVIATIONS

	Class I	Class II	Class III	Class IV
λ	0.259222	0.214808	0.258265	0.139311
λ_T	0.235901	0.206028	0.234928	0.121978
H	0.541157	0.218451	0.46823	0.164886
H_T	0.56311	0.285407	0.497374	0.110604

CONCLUSION

With this data in mind, we can look back at the previous 4 graphs and see that this pattern is true amongst the λ graph. Furthermore, the higher ALL of the values (λ , λ_T , H , H_T) are, the more likely the classification is going to be IV. The behaviour of all of the graphs relate, where all instances of Class IV structures is beyond the midway point of the graph. There also exist Class I, II, and III structures at these points. There also exist Class III behaviour within the regions of Class I and II areas. Such anomalies shown to be possible because of the standard deviation computed up above. And the values clearly support the graphs. Notice how Class IV's standard deviation for λ , λ_T , H , H_T all support the claim about how it is toward the very end of the graph in all 4 cases, and also has the smallest variation. Classes I and III vary the most in the graphs, hence how they have the largest standard deviation. These anomalies are also potentially possible because of entropy. Put simply, the higher the entropy is, the more "chaotic" the system is. Hence the name of the assignment in a nutshell, being the "Edge of Chaos".