Homework 2 Write-Up

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(Dated: February 16, 2024)

1. EXERCISE 3.1 PLOTTING EXPERIMENTAL DATA

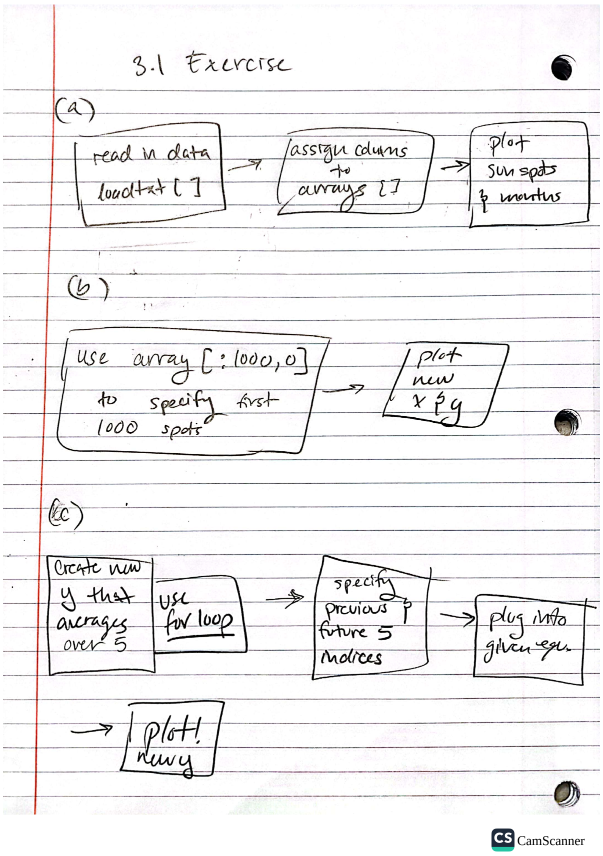

FIG. 1: Flow-chart for Exercise 3.1.

This exercise uses data from a file called sunspots.txt. I plotted the number of sunspots on the Sun for each month since Jan. 1749. First, I plotted all of the sunspots 2, then only the ones in the the first thousand months 3. I did this by making an array of the first set of data (the sunspot numbers) and another array for the months, then plotted then as my x and y for Part (a) and (b).

For Part (c), I calculated and plotted the running average where r = 5. I did this by taking the average of the 5 data points of sunspots before and after a certain point defined by an index and using the average to plot that point at the specified index 4. To plot both the running average over the original data I just didn't close the first plot 5. Then again only took the first 1000 points using the array indices 6. To solve the problem of not having enough data for a running average for the first 5 data points, I omitted those first 5 points from the running average calculations.

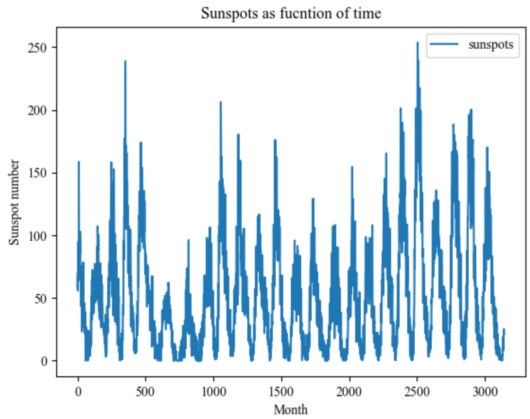

FIG. 2: Number of Sunspots over Months since 1749.

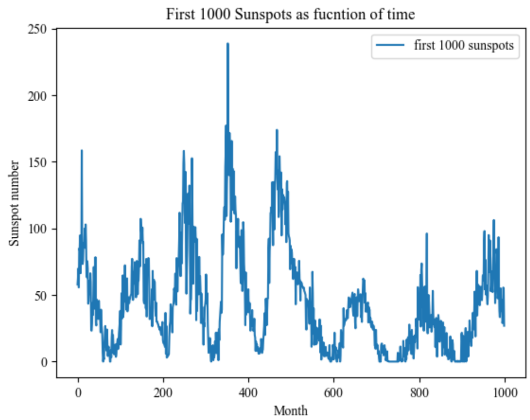

FIG. 3: First 1000 Sunspots over Months since 1749.

$$Y_k = (1/(2r+1)) \sum_{m=-r}^{r} y_{k+m} \quad (1)$$

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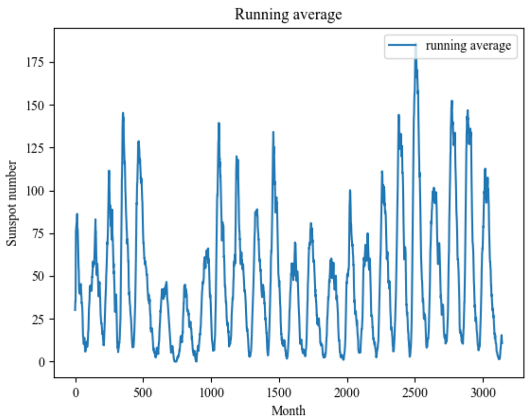

FIG. 4: Running average of sunspots.

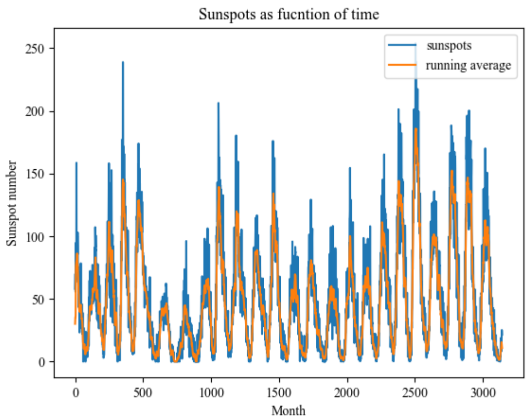

FIG. 5: Running average overlaid on original data.

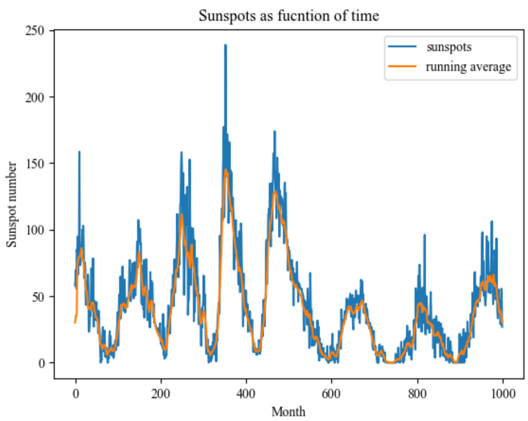

FIG. 6: First 1000 of overlaid data.

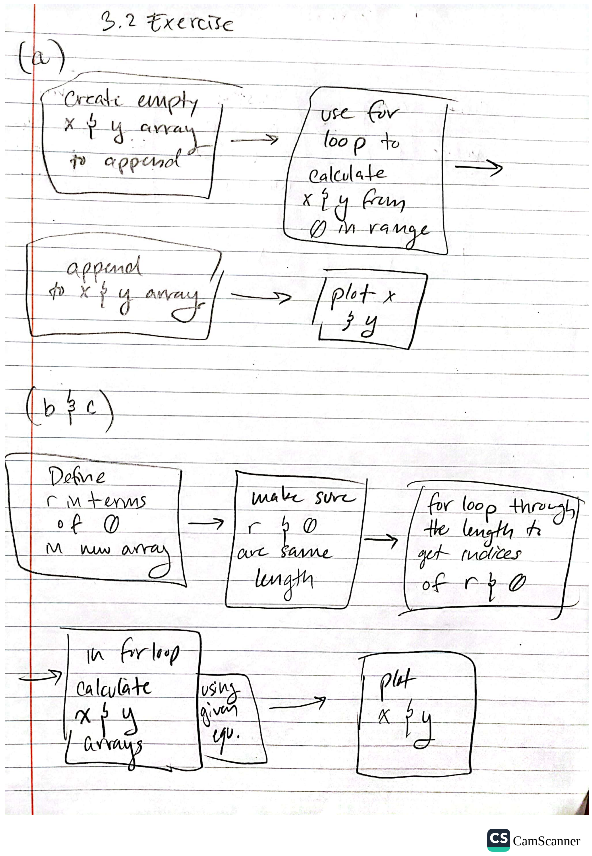

FIG. 7: Flow-chart for Exercise 3.2.

2. EXERCISE 3.2 CURVE PLOTTING

For this exercise, I created a deltoid curve by first creating two empty arrays to which I then appended the outputs of a for loop which calculated x and y from the set ranges of θ and Equations 2 and 3 [8].

$$x = 2cos(\theta) + cos(2\theta) \text{ where } 0 \leq \theta \leq 2\pi \tag{2}$$

$$y = 2sin(\theta) - sin(2\theta) \text{ where } 0 \leq \theta \leq 2\pi \tag{3}$$

For Part (b), I make a plot of a Galilean spiral by converting polar coordinates with the parameters for r defined in Equation (4), to Cartesian coordinates. I did the same thing as in Part (a) with a new set of arrays and Equations (5) and (6) [9].

$$r = (\theta)^2 \text{ where } 0 \leq \theta \leq 10\pi \tag{4}$$

$$x = rcos(\theta) \tag{5}$$

$$y = 2sin(\theta) \tag{6}$$

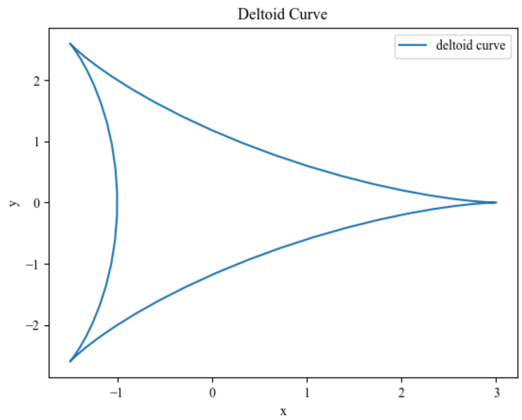

FIG. 8: Deltoid Curve.

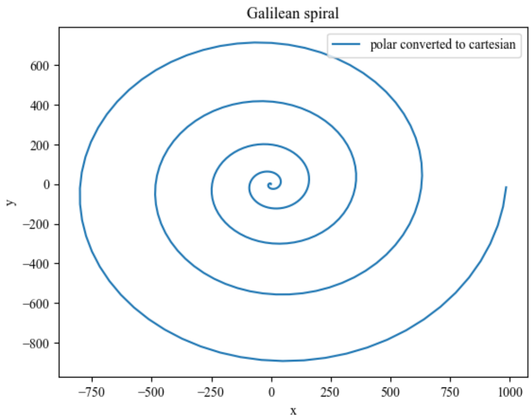

FIG. 9: Galilean Spiral.

For the last part of this exercise, I used the same method as in Part (b) with Equation (7) defining r, to plot Fey's Function 10.

$$r = exp(cos(\theta)) - 2cos(4\theta)) + (sin(\theta/12))^5 \text{ where } 0 \leq \theta \leq 24\pi \tag{7}$$

3. EXERCISE 3.6 DETERMINISTIC CHAOS

In this exercise we are asked to plot the Feigenbaum plot 12, an iterative map from Equation (8) to answer some questions about it. I found that from r=1 to approximately r=3, the Feigenbaum plot shows a fixed plot, from r=3 to r=3.5, it settles into a limit cycle, and for r values greater than 3.5 the system moved to chaotic behavior. A fixed point in the iteration can be identified as a line, while a limit cycle jumps between 2 to say 4 values to create orderly bifurcations which look like 'loops'. Chaotic behavior looks random even though it is not.

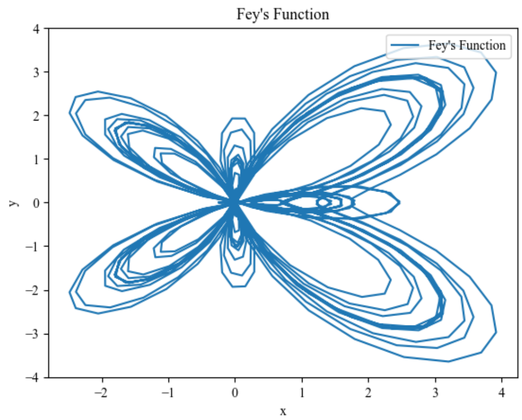

FIG. 10: Fey's Function.

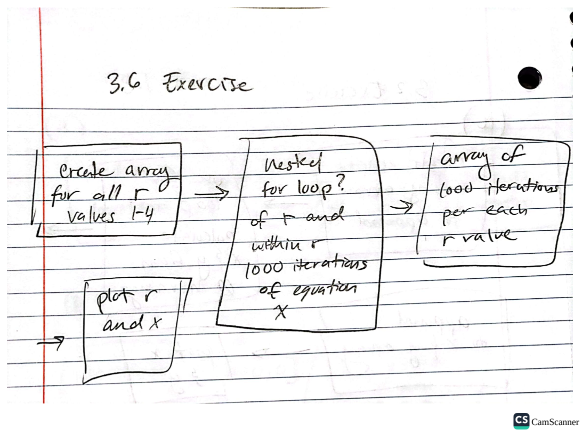

FIG. 11: Flow-chart for Exercise 3.6.

$$x' = rx(1 - x) \tag{8}$$

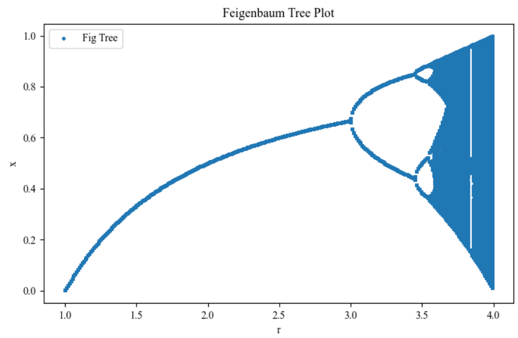

FIG. 12: Feigenbaum Tree Plot.

4. SURVEY QUESTIONS

The homework this week took approximately 10 hours. I learned how to use for loops and how to use matplotlib to create nice(ish) looking plots. I thought the problems were each reasonable and fun, but as someone with less coding experience it took a while.