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Implementation Summary

Objective

Using the Mars oppositions data, find the best parameters to represent the Equant, center and radius of mars's circular orbit, and the angle the equant and center makes with the sun, which is situated at the origin. Also, find the optimum angular velocity of mars about the sun so as to minimize the oppositions longitude discrepancy.

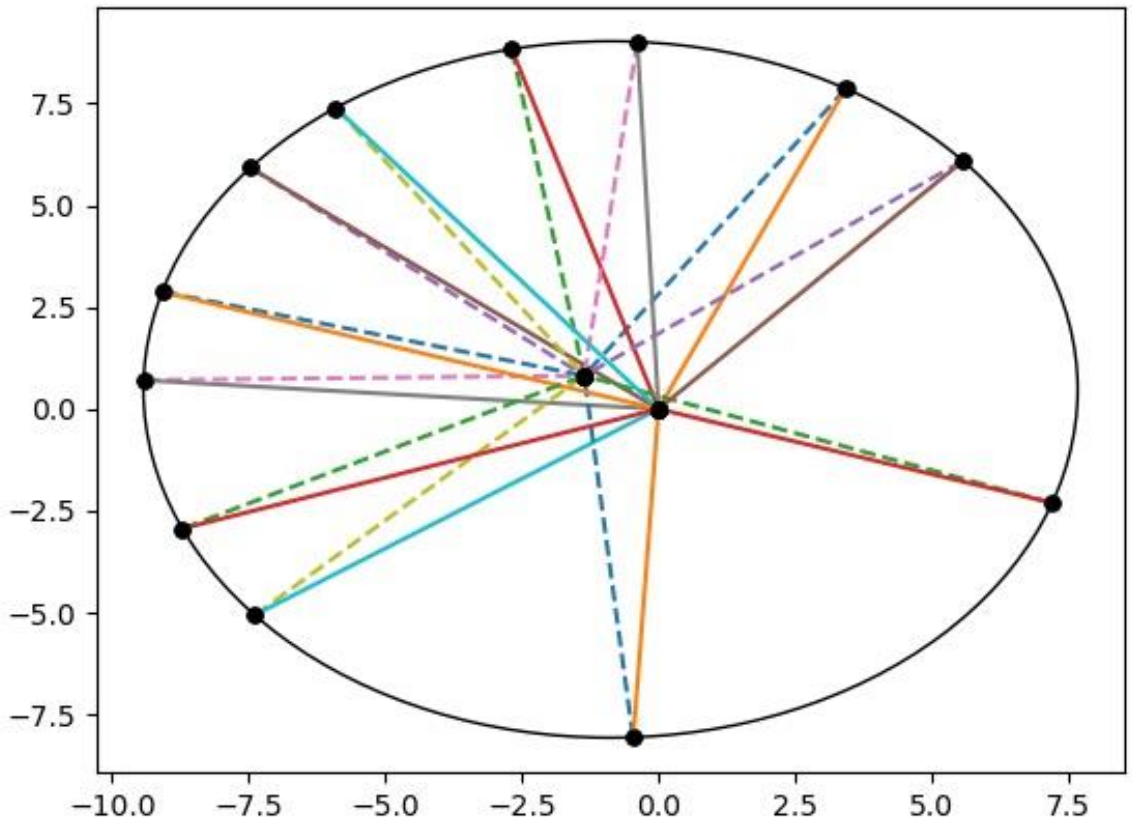
Libraries Used

Numpy, Pandas, Matplotlib, Datetime, Scipy

Procedure

- Imported the required libraries and extracted the data from the csv file provided.
- Calculated the necessary “times” and “oppositions” from the data.
- Scripted functions to calculate roots of a quadratic equation and plot the final graph which mimics the plot given on slide 31.
- Wrote answer to 1st question
    - I pass the variables (c,e1,e2,z) as a tuple and then unpack it.
    - I tried using the SYMPY library. It was yielding results but the optimization step was taking much longer.
- Before writing the code to the 2nd question, I wrote a few short scripts that enabled me to optimize the parameters (c,z,e1,e2) individually. The 2nd function employs the 1st one.
- Then I tried all the permutations possible of (c,z,e1,e2) to find the best sequence, which came out to be (e1,z,c,e2). I optimized all the parameters one by one at first, and then all at once using minimize_scalar and minimize functions of scipy respectively.
- In the 3rd answer, I performed a brute search over a range of S very close to 2(pi)/687 by invoking the second function.
- In the 4th answer, I again performed a brute search over a range of R which was obtained empirically by hit and trial method.
- In the 5th question, I performed a discretized brute search for an optimal **r** and **s** over the ranges mentioned above. This function invoked the 2nd one, which performed a optimization operation to reduce the maxError, in turn, returning us the values of c,e1,e2,z in every iteration.
- Finally, with the help of the Plotting function and the optimal parameters acquired, I plotted the graph. The circle here is the center of the circle obtained with a radius **r**. The dotted lined represent the lines joining the Equant to the circle at the opposition positions using the calculated longitudes. The solid lines represent the lines joining the Sun to the circle at the oppositions using the observed(and provided) heliocentric longitudes.

Results



The parameters obtained after optimization are as follows:

Parameters	**Values**
C	151.3712º
Z	55.7812º
E1	1.5877 unit
E2	148.9599º
	8.5450 unit
S	0. 00916398095 rad/day
MAXERROR	0.0415176º(2.491 minute)