Space Operations Take Home Test

Space Systems Engineer

As a Space Systems Engineer within the Space Operations team, you will be exposed to a great amount of information about the status of the fleet. This information is often found in several different places and it is not always presented in a simple fashion. Part of the job is therefore to retrieve and present the data in a way that makes you understand and recognize anomalies in the system, in order to decide which is the best course of action to mitigate the problems.

In this exercise, you will work with a small subset of the Dove constellation (which has more than a hundred satellites in operation). The information that you will have about the seven satellites in question will be the telemetry reads of 9 of the sensors onboard the satellites, as well as the beta angle of their orbits, both in the form of CSV (Comma Separated Variables). You will be asked to present the information in an easy to understand way and to analyze it after. The result that you are expected to provide is a **.zip** file consisting of:

- A **Python script**, with a reasonable amount of comments to make it easy to read
- A certain number of plots in a **.png** or **.jpg** format
- A **text file** (pdf or a simple .txt) providing answers to the questions that are asked

Some notes:

- Under nominal conditions, the satellites have 3 gyros and 4 wheels active, which get saturated at 8000rpm
- The telemetry channel under the name “low_voltage” is a flag triggered by the satellite when it detects that the voltage of its bus is below a certain threshold. As a result, the satellite will inhibit some of its hardware such as the camera
- Gyro rates are expressed in degrees per second, wheel speeds are in rpm, voltage is in volts
- Values that are empty or not a number are due to the lack of a measurement at that epoch
- The satellites are named following the phonetic alphabet (alfa, bravo, charlie…)

Special remarks:

- Try to make the code as clean and efficient as possible
- If possible, try to keep your questions concise, a couple of sentences can be enough
- When plotting graphs, make them easy to read and understand, with clear labels and specifying the units
- As part of your code, include print line outputting the **time** required to run in total and between each major step

Questions

1. Develop a Python script that is able to retrieve all the data from the CSV files, filter the data to make it presentable and plot the following (attach also the graphs):

    a. All the telemetry channels of each satellite in a single page (all gyros and wheels together)

    b. All the telemetry channels of all the satellites combined in a single page

    c. The beta angle of all the satellites, combined in a single graph

    d. Optional: Add (and explain) any other plots that you find helpful when exploring the data set

2. For each satellite, compute the percentage of the available telemetry points where:

    a. The wheels get saturated at their maximum speeds (average for all of the active wheels)

    b. The low voltage flag is active

    c. The gyro rates are over two degrees per second (average for all axes)

3. In light of the results, provide an answer to the following questions:

    a. The SkySat constellation is divided into what we call “flocks” of satellites, which are batches of satellites launched at the same time by the same vehicle. How many flocks can you distinguish in these 7 satellites? How can you tell? Which satellites belong to each flock?

    b. From the plots, some satellites clearly show certain anomalies that could potentially be dangerous for their operations, can you identify at least three of them? There is no need to conjecture about the reasons for it yet, one or two sentences could be enough.

4. For the anomalies identified, create a separate Python function that:

    a. Takes as input a telemetry channel.

b. Returns a boolean, specifying if the issue in question is present (True) or not (False). There should not be false positives.

5. Can you guess or infer, in light of the results and your knowledge of satellite systems, what could be the reason behind each of the anomalies that you identified?

6. What can you think of as a response to the problems that you observed in order to mitigate their impact or reverse the issues?

7. In this exercise you were only provided with 9 telemetry channels and one aspect of the orbit of the satellites, whereas in reality there are hundreds of telemetry channels and metrics available in the system.

    a. What other telemetry channels can you think of that would help you assess the health of the satellites?

    b. What higher level metrics could tell you about the global performance of the constellation, not only in terms of satellite health but also productivity? Can you think of one that is more important than the rest?

8. How would you face the need to perform an analysis like this, but to a fleet of 100 satellites and on a daily basis?