Problem Formulation

Reinforcement Learning Model for Scientific Discovery on a planetary body

Objective:

The objective of this project is to design and implement a proof-of-concept reinforcement learning model that can detect scientific phenomena on a planetary body (e.g. water plumes on Enceladus, methane detection on Mars, Volcano detection on Io, etc.) and navigate a spacecraft towards the source of the plume for detection and analysis. The model should incorporate online learning to continually learn and adapt to its environment during the detection process.

Project Requirements:

1. Implement a reinforcement learning model for online learning in the context of a simulation environment for detecting plumes on Enceladus (or another similar scientific phenomenon on another planetary body – your choice).
2. The model should guide a spacecraft to move towards the source of a detected plume and reach it for analysis.
3. The model should be able to dynamically adapt and learn from its interactions with the environment.
    - For example, if the trained model runs into a new obstacle, let's say, an ice geyser instead of a water geyser (which is actually still quite interesting, but for this problem, we'll say we only want to detect water vapor) it should be able to learn from this scenario and update its policy. Another example could be certain extremes of surface temperature variation that give the sensors a false positive or negative. Or high areas of radiation, which cause false positives or negatives in the sensors, and have the potential to damage them and the spacecraft.

You have the freedom to approach this problem in any way you see fit. Please feel free to ask questions regarding the available state information, or any other details that you think may be relevant to your solution.

Although you have the freedom to choose your own simulation setup, we encourage using Pybullet for the physical simulations due to its realistic and accurate physics engine, as well as being compatible with our own research and development at NASA.
It is also recommended that you set up your reinforcement learning environment within the Gym framework. This will provide a standardized and flexible environment for developing and comparing your reinforcement learning algorithms.

We also encourage open sourcing this if it seems reasonable to at the end! We can benchmark it against our own research here. Of course, *all* credit will go to whomever credit is due.

Deliverables:

1. A report detailing the design and implementation of your reinforcement learning model, including any challenges faced and how they were addressed.
2. A demonstration of the model detecting and navigating towards a plume on Enceladus, including the model's learning process.

Sources for further reading:

- Pybullet: https://pybullet.org/wordpress/index.php/forum-2/
- Gym framework: https://github.com/Farama-Foundation/Gymnasium