

Polaris: Machine Learning for Satellites



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Cubesat Developers Workshop, May 2020

- Visit us at <https://polarismml.space>



Outline

- What is Polaris?
- Live demo
- What would you like from Polaris?
- Join us!


<https://polarism1.space> 

“An open source Python tool for exploring and analyzing telemetry data obtained from the SatNOGS network”



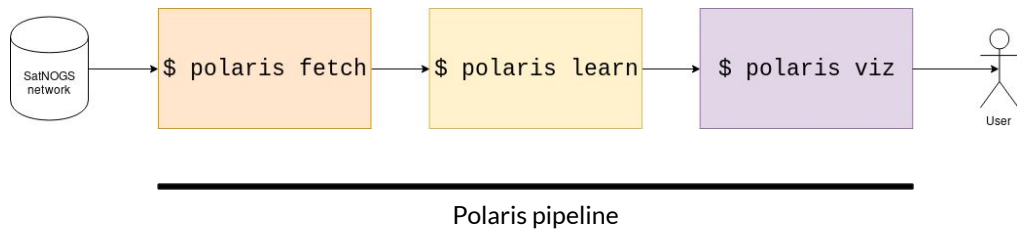
- Begun in 2018, after the 2nd Open Source Cubesat Workshop (<https://oscw.space/>) in Madrid, Spain.
- We have 12 contributors, from > 5 countries over 3 continents. 518 commits, 104 merge requests.
- In 2019, we participated in the Google Summer of Code and the European Space Agency's Summer of Code in Space.
- We are grateful to SatNOGS (<https://satnogs.org/>) for publishing the data they collect (<https://db.satnogs.org>). You can see their network of ground stations (>200 at last count) at <https://network.satnogs.org/>.



Our goal:

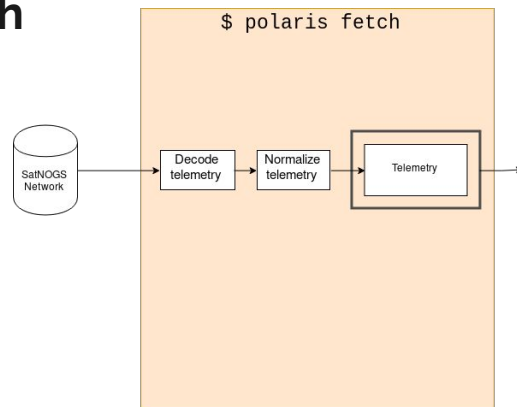
To pave the way toward open source, autonomous satellite operations for missions at all scales, anywhere in the solar system.

The architecture



- Fetch: download and normalize data for a particular satellite/time
- Learn: analyze and build a model for that satellite
- Viz: show and explore the dependency graph

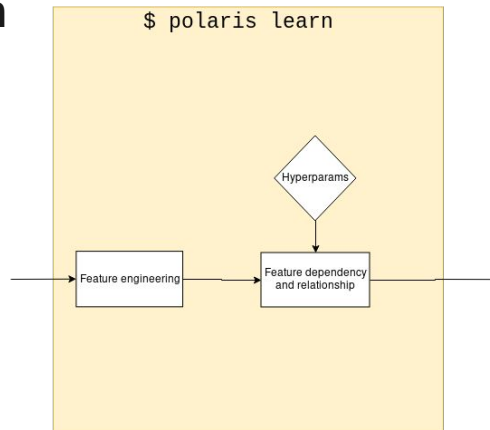
polaris fetch



- “polaris fetch” downloads elemetry for a particular satellite, over a particular time range
- Note: we can only download *telemetry*, as opposed to raw data, if the satellite operator publishes specifications for their telemetry. Without that, we’re unable to analyze it with Polaris.



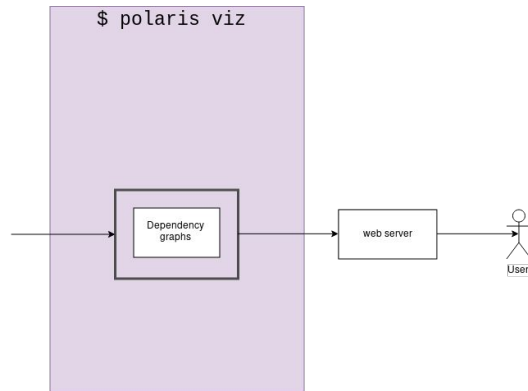
polaris learn



- We currently use XGBoost
- We generate a dependency graph for the satellite telemetry, and save that in JSON format. This can be displayed by “polaris viz”, but can also serve as the input for other tools.



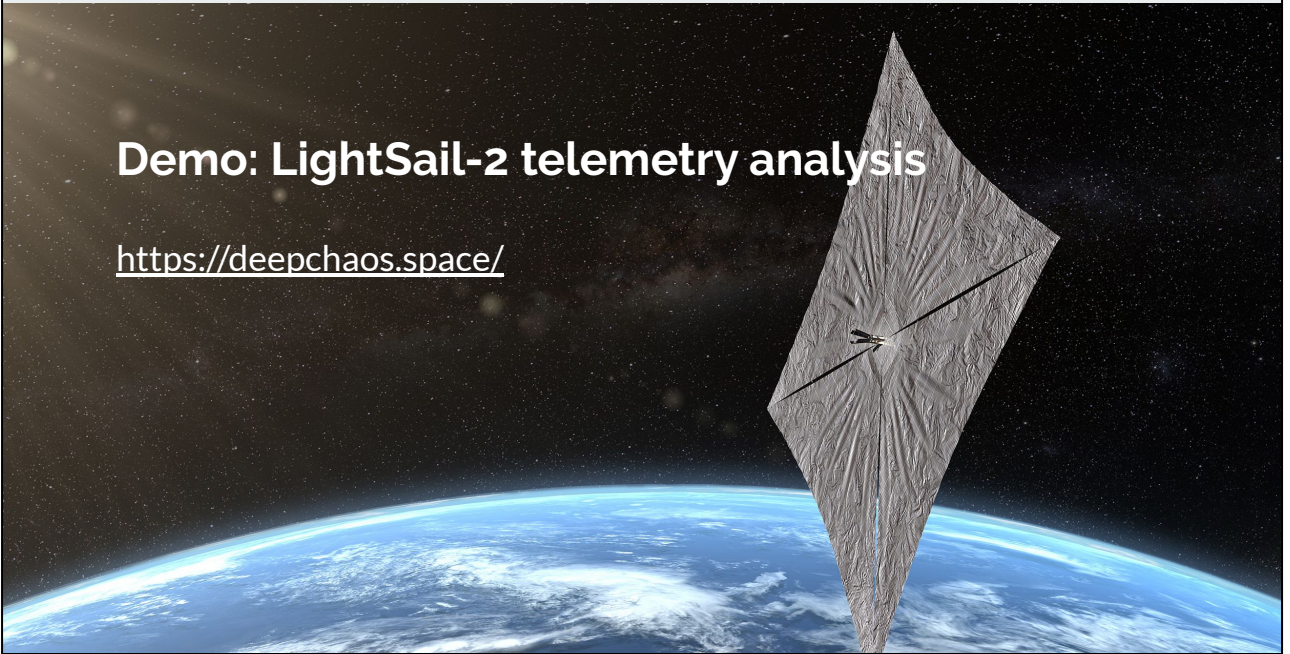
polaris viz



- "Polaris viz" allows the user to interact with the dependency graph using a 3D visualization displayed in their browser.
- The user can search for telemetry items, and highlight nodes that match a naming pattern ("bat", "temp", etc).

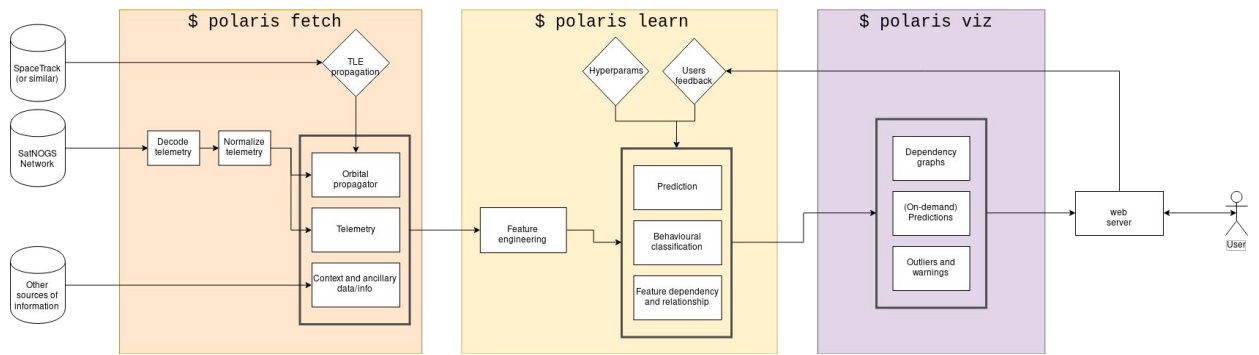
Demo: LightSail-2 telemetry analysis

<https://deepchaos.space/>



- You can read more about the LightSail-2 project at <https://www.planetary.org/explore/projects/lightsail-solar-sailing/>
- We are very grateful to the Planetary Society for publishing their telemetry specification.
- You can see and interact with the demo at <https://deepchaos.space>
- It's worth emphasizing that this graph was generated entirely using machine learning -- no human effort was required to make this.
- The nodes searched for were "datafree", "cam1_pics_remaining" and magnetometer readings (all beginning with "mag_").
 - No satellites were harmed in the making of this demo.

Next steps



- For polaris fetch: download TLEs for satellites, and do orbital propagation; support additional contextual information (commands sent, space weather events, etc)
- For polaris learn: add predictions; add behavioural classification; incorporate user feedback; give the user more flexibility in hyperparameter tuning
- For polaris viz: highlight outliers and warnings for the operator; show predictions and support on-demand predictions; generate more dependency graphs for more satellites
- We would love to hear from you! Please join us at <https://polarism.space> and tell us what would make Polaris more useful to YOU.



Conclusions

- We have already found interesting things with fairly simple analysis
- We will need to collaborate with satellite operators to validate the results
- More data will yield even better results
 - Publish those telemetry specifications!



Want to contribute?

 polarism1.space

 riot.im/app/#/room/#polaris:matrix.org

 gitlab.com/crespum/polaris / LGPL v3

Thanks for watching!

- Please visit us at <https://polarism1.space>
- We look forward to talking with you!