

Artificial Intelligence and Analytics in JPL's Innovation Experience Center Ground System Architectures Workshop (GSAW) Session 12A

Chris A. Mattmann – Deputy CTO, Chief Technology and Innovation Office Office of the Chief Information Officer March 5, 2020

Many thanks to Valentino Constantinou, and Tom Soderstrom for contributions to these slides!!



The Chief Technology and Innovation Office Today

Purpose

- Envision and evaluate the future IT technologies needed by OCIO, JPL and NASA
- **Detect** and infuse innovation and technology into projects/missions, business, science and engineering
- Engage promising industry partners for OCIO and JPL's benefit
- Infuse future talent into OCIO and JPL
- Train JPLers in new IT technologies and ways of working

How can we infuse emerging technologies into the enterprise?

Enjoy the benefits of surfing (<u>user experience</u>) and leverage the power and future of the wave (<u>back end</u>) and spend time doing it (<u>priorities and focus</u>)

WHAT ARE THE EMERGING TECHNOLOGY WAVES?



HOW DO WE MAKE IT LIMITLESS?

Participate at: techwaves@jpl.nasa.gov



WHAT ARE THE EMERGING TECHNOLOGY WAVES?

New Habits

Work from anywhere, always connected, gaming, sharing, open source, reduced footprint, cord-cutting

Applied Al

Deep Learning, Machine Learning, IA, Intelligent Digital Assistants, NLP, automation, data-driven, APIs, analytics, combinations

Ubiquitous Computing

Mobile, smart devices, AR, IoT, NUI

BUILT-IN INTELLIGENCE

Cyber Security Challenges

At scale, authentication, encryption by default, rolebased training, BlockChain

Accelerated Computing

Serverless, edge computing, HPC, GPUs, Neuromorphic, Quantum

Software Defined Everything

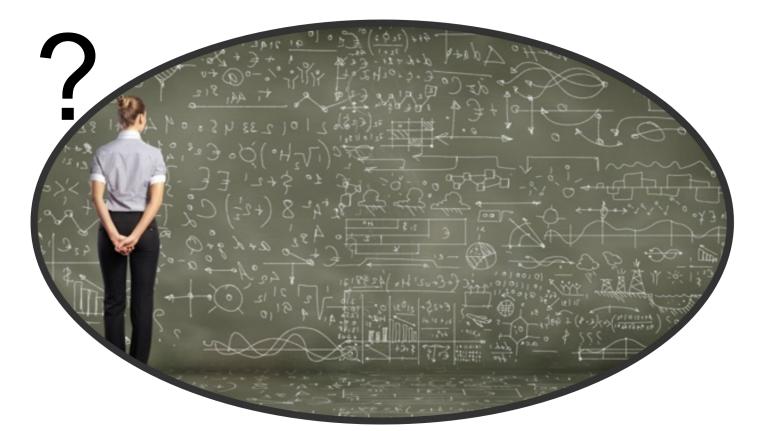
Programming everything, APIs, Software Defined Networks, containers, DevOps, Open Source, self-healing, everything distributed



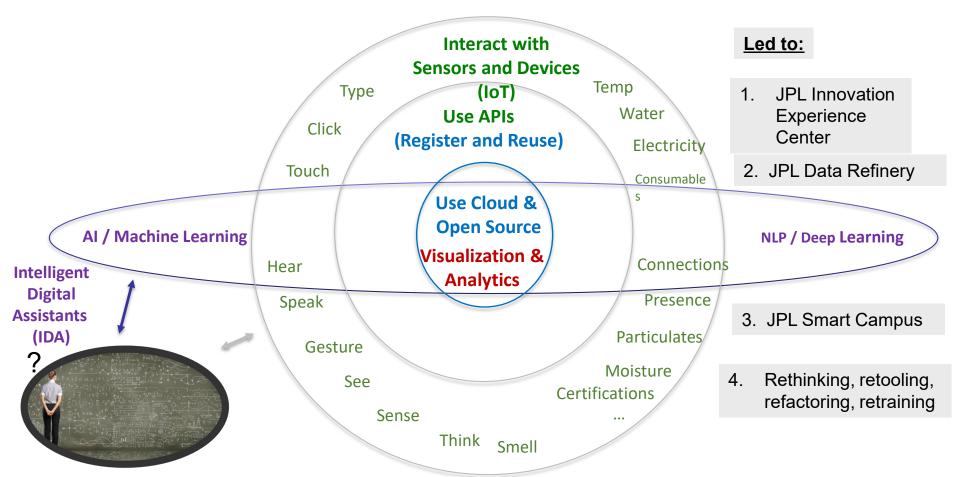
HOW DO WE MAKE IT LIMITLESS?

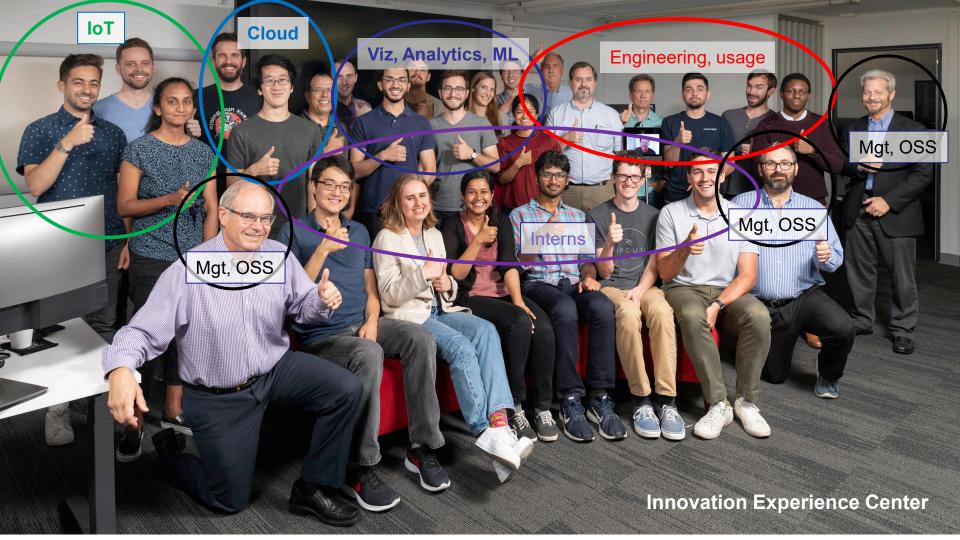
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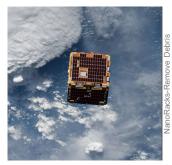
How do we find answers? How do we detect new questions?



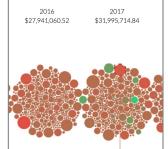
We apply the key emerging technologies to help



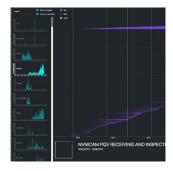




Small Satellite Data Science



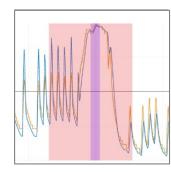
Visual Financial Analytics



BETR



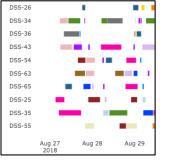
EXCALIBUR Exoplanet Classifier



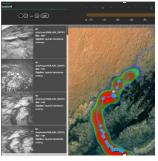
Telemanom Anomaly Detection

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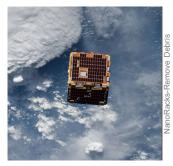
Alarm Management



DSN Scheduling



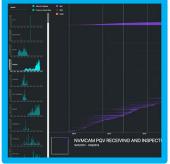
MAARS Image Captioning



Small Satellite Data Science



Visual Financial Analytics

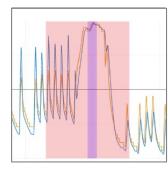


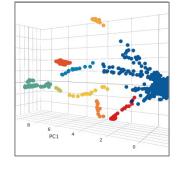
BETR



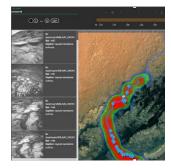
work of the Studio







DSS-26 DSS-34 DSS-36 DSS-43 DSS-54 DSS-63 DSS-65 DSS-25 DSS-35 DSS-55 Aug 29 Aug 27 2018 Aug 28

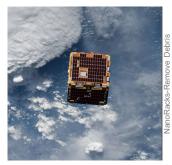


Telemanom **Anomaly Detection**

Alarm Management

DSN Scheduling

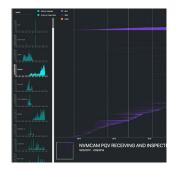
MAARS Image Captioning



Small Satellite Data Science



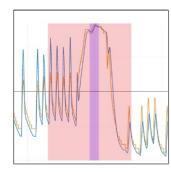
Visual Financial Analytics

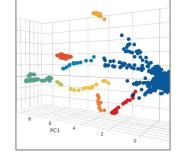


BETR



EXCALIBUR Exoplanet Classifier





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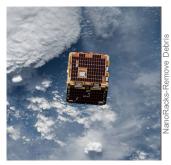


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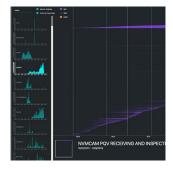
MAARS Image Captioning



Small Satellite Data Science



Visual Financial Analytics

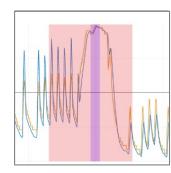


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work of the Studio

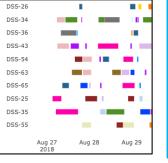
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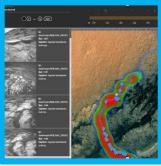
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Alarm Management



DSN Scheduling

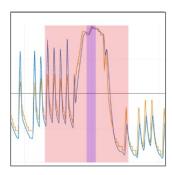


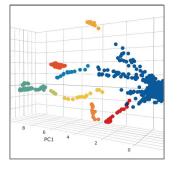
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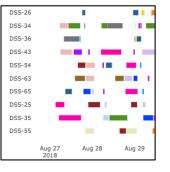


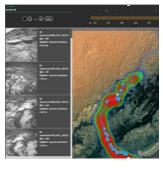
Foundry Data Science

BETR









Telemanom Anomaly Detection

Alarm Management

DSN Scheduling

MAARS Image Captioning

Mission Formulation and Planning

Mission Operations

Mission Formulation and Planning



Natural Language Processing (NLP) for Information Retrieval

JPL JPL Space JPL Caltech NASA	
A-Team Tool Search	
Search Tool Crawl Tool SME Discovery Saved Items	Getting Started Data Info
Search d	latabases for relevant information.
Select sources to search:	
JPL Sources ✓ A-Team Wie ⑦ → RATO (Reports, Awards, Posters, DRDF) ⑦ ✓ Microwave Limb Sounder (MLS) Publications ⑦	NASA Sources: External Sources: ✓ Techoot ① ✓ NTIS / Search Analytics ① ✓ SBIR ① ✓ Do ① ✓ NASA ② ✓ MSF ③ ✓ Larth Science Decadal Survey ⑦
Uncheck All Selections	Save Checked Selections Export Checked Selections
- Year (RATD) 19 cont 4 cm	200 205 2015 2020
2017 (25)	1 – 100 of 7712 next »
	Laist Updare 1/10/2019. smmentz: Context - Valentino Constantinou Website - Paul Zimdans d research and development center staff and managed for NABA by Caltech
	BETA version: report bugs or share your feedback submit feedback

Analytics and machine learning aids early mission technology concept research and formulation.





Natural Language Processing (NLP) for Information Retrieval

Analytics and machine learning aids early mission technology concept research and formulation.

"one major advantage ... is to "one-stocklydaanskof avord Stilling this Inforchativer [effbotst.highthresvilse) accessing the series of others) is the can be very time-consuming." - Morgan Cable (3225 – Astrobiology - Morgan Cable (3225 – Astrobiology and Ocean Worlds)



Natural Language Processing (NLP) for Information Retrieval

odel	Home Applicat
The below visualization, LDAvis, is an interactive visualization of the topics estimated using Use the selector buttons below to choose a solicitation and debrief type.	g Latent Dirichlet Allocation. An LDA model has been fit to each type of debrief per solicitation.
Solicitation	Debrief Type
Earth Venture Mission - 2 / NNH15ZDA0110 - EVM-2	Major Weakness •
The left visualization shows a global view of the topics, plotted in a 2 dimensional space that represents the variance between the topics. Topics that are close to each other in the space are more similar to each other. The area of the circle is proportional to the prevalence of the topic in the corpus. You can use the slider to adjust the value of lambda, a weighting parameter used to calcul specific topic and across all topics. A lambda value of 1 highlights the term's importance we	topic specific frequency of the term. Hover over a topic in the left hand visualization, or select the topic from the drop down menu, to see the terms in the topic. late relevance of a term. Relevance of a term is a combination of term importance within a
compared to other topics. Typically a lambda value of 0.6 is recommended to better under	
Selected Topic: 3 Previous Topic Next Topic Clear Topic	Slide to adjust relevance metric: ⁽²⁾
	λ = 0.6 0.0 0.2 0.4 0.6 0.8 1.0
	naisto Exale- teste asun Actacater asun Control Bar angigto Actacater asun Control Bar asun Control Bar asun Control Bar asun Control Bar asun Control Bar asun Control Bar asun Control Bar asun Control Bar asun Control Con
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-20	GSAW2

Analytics and machine learning **uncovers patterns in debriefs** which can be used to improve future proposals.





Natural Language Processing (NLP) for Information Retrieval

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Selected Topic: 3 Previous Topic Next Topic Clear Topic		Slide to adjust relevance metric: ⁽²⁾ $\lambda = 0.6$	0.0 0.2 0.4	0.6 0.8	1.0	
Intertopic Distance Map (via multidimensional scaling)		Top-30 Most Relevant Te	erms for Topic 3 (13.1%	of tokens)		
PC2		2 4	6 8	10		
	sno					
	radiati					
4	transf spectromet					
13	albec					
5	backscattere assum					
	determin					
8	sid forcir					
14	shap					
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PC1 16 12 7 3	surfac	•				
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10	resu					
	gra conditio					
	lig					
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2	9					
	implicit	si se s i si				
Marginal topic distribution	datas	et en e l el				
		Overall term frequency				
() 2%		Estimated term frequency within the	selected topic			
5%		$\label{eq:linear} \begin{array}{l} 1. \mbox{ saliency(term w) = frequency(w) * [sum_t p(t] \\ 2. \mbox{ relevance(term w topic t) = } \lambda * p(w t) + (1 - 1) \end{array}$			(2012)	
R-20				G	SAW20	

Analytics and machine learning **uncovers patterns in debriefs** which can be used to improve future proposals.

The A-Team and Proposal Debrief Tool reduce concept and proposal research effort while introducing new research capabilities.



Business Event Transaction Registry (BETR)

An Institutional Framework for Monitoring Lifecycles

BETR is a tool that provides the ability to **examine** engineering footprint in a common way.





Business Event Transaction Registry (BETR)

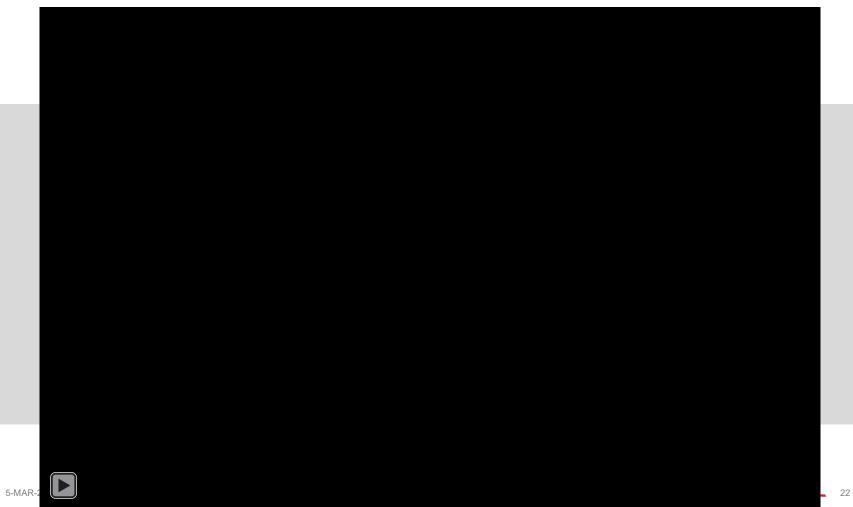
An Institutional Framework for Monitoring Lifecycles

BETR is a tool that provides the ability to **examine** engineering footprint in a common way.

We can now start to examine processes across several areas of JPL seamlessly, and use analytics and visualization for monitoring and improvement.







Mission Formulation and Planning

Mission Operations

Optimization of DSN Scheduling

Decrease Human-in-the-Loop Time for Mission Scheduling

Missions make requests to the DSN months (sometimes years) in advance to ensure coverage for science and operations.



Optimization of DSN Scheduling

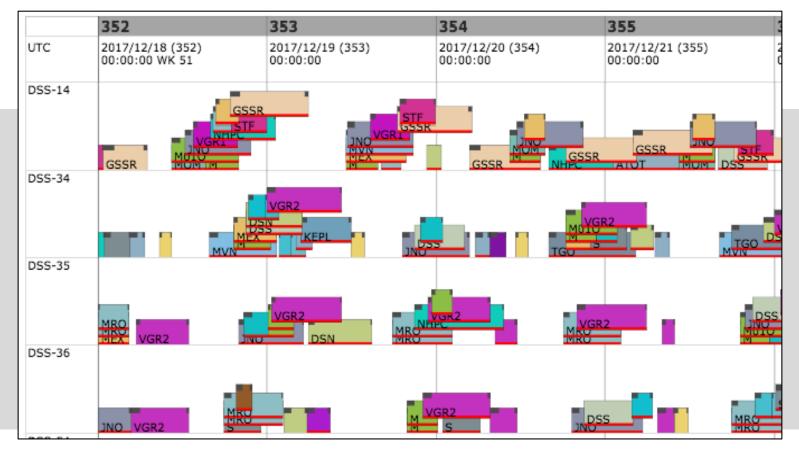
Decrease Human-in-the-Loop Time for Mission Scheduling

Missions make requests to the DSN months (sometimes years) in advance to ensure coverage for science and operations.

Scheduling is always difficult due to overlapping requirements. Our current tools work – but require manual labor.



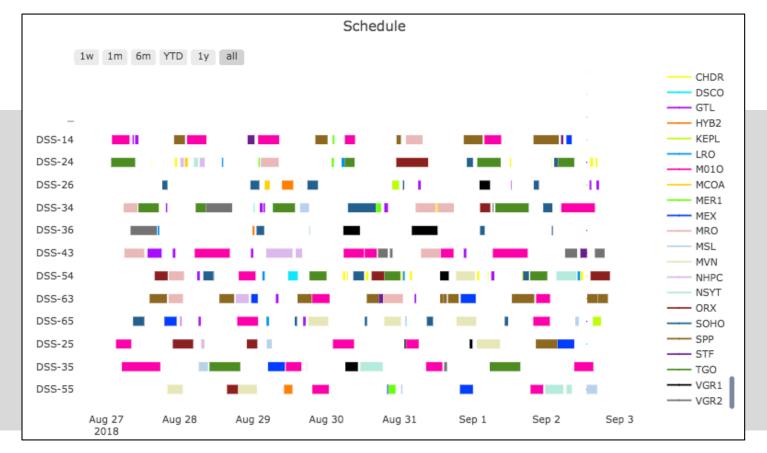
DEEP SPACE NETWORK



S³ tool showing "conflicting" tracking requests before any scheduling resolution.

GSAW2020

DEEP SPACE NETWORK



Visualized output from use of reinforcement learning (RL) and multi-integer linear programming (MILP) approach.

GSAW2020



5-MAR-20



MAARS Rover Image Captioning

Increasing Science Throughput with On-Board Deep Learning

High Performance Spaceflight Computer (HPSC) will power the next generation of surface vehicles.





MAARS Rover Image Captioning

Increasing Science Throughput with On-Board Deep Learning

High Performance Spaceflight Computer (HPSC) will power the next generation of surface vehicles.

Instead of 200 images per day for scientific analysis and target selection – what about 1 million captions?





MAARS Rover Image Captioning

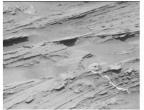
Increasing Science Throughput with On-Board Deep Learning



sedimentary bedrock overlying light toned bedrock and regolith



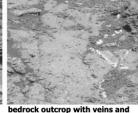
rover arm over fractured sedimentary bedrock



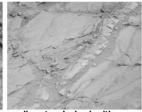
sedimentary bedrock with planar and crossbedded layers and veins



crossbedded bedrock outcrops with sand



nodular textures



sedimentary bedrock with alteration halo



close view of a conglomerate rock selfie of the rover on regolith and



bedrock

the view of an outcrop surrounded by sand dunes



dark sand dune field in front of layered strata .



coarsely layered sandstone and sand



bedrock with many veins surrounded by sand and regolith









Telemanom Time Series Anomaly Detection

Application to Spacecraft and Mission Operations

Monitoring thousands of telemetry channels for changes in behavior is prohibitively difficult and time-consuming.







Telemanom Time Series Anomaly Detection

Application to Spacecraft and Mission Operations

Monitoring thousands of telemetry channels for changes in behavior is prohibitively difficult and time-consuming.

A modeling and software architecture for any time-series data – today's focus on enhancing mission operations.

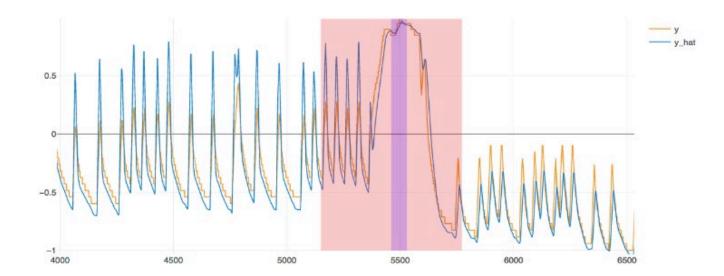






Telemanom Time Series Anomaly Detection

Application to Spacecraft and Mission Operations



y / y_hat comparison

A detection of contextual anomaly using Telemanom on Mars Science Laboratory thermal channels.

GSAW2020







Characterization and Prioritization of Detected Anomalies

In a critical scenario, hundreds of alarms could be active at any moment across multiple telemetry channels.

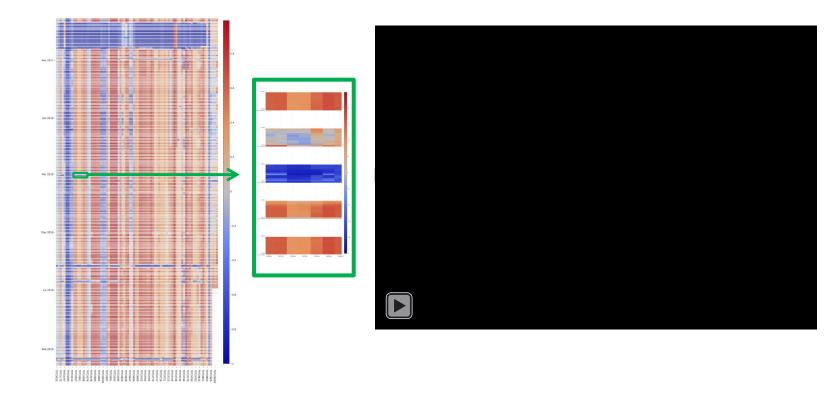


Characterization and Prioritization of Detected Anomalies

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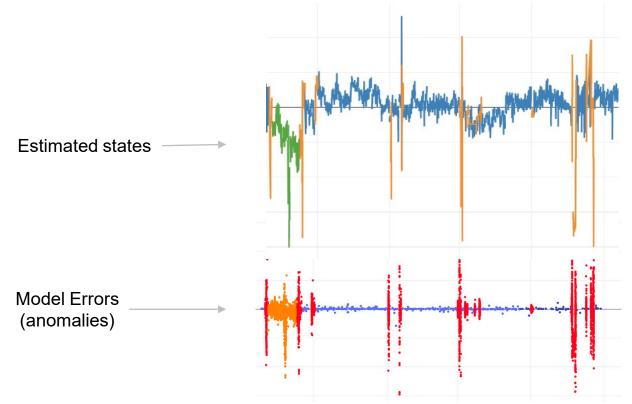
Alarm management is developing methodologies in alarm prioritization, fault detection, and state estimation – extensions being researched that complement previous and current work.

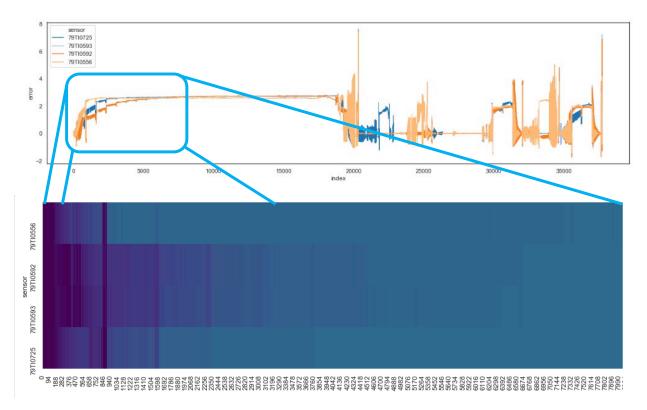


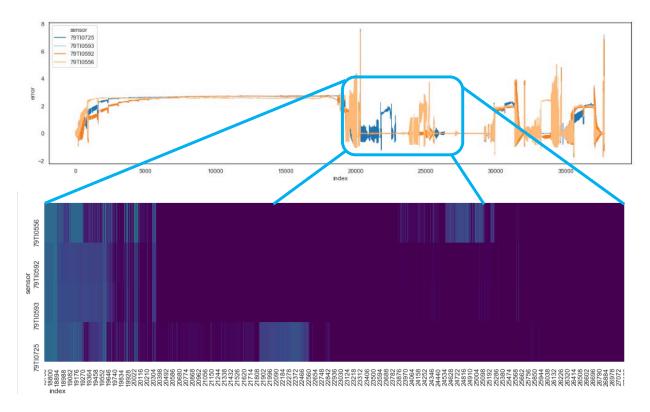


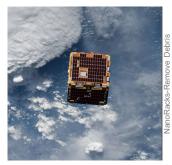
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Alarm (Anomaly) Management

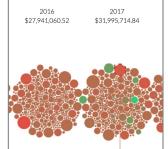




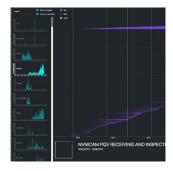




Small Satellite Data Science



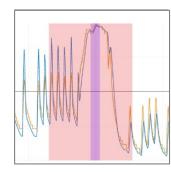
Visual Financial Analytics



BETR



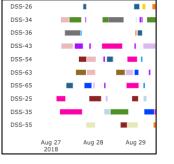
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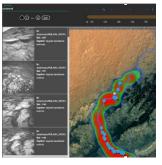
Telemanom Anomaly Detection

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Alarm Management



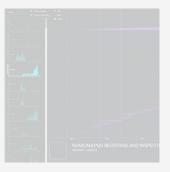
DSN Scheduling



MAARS Image Captioning





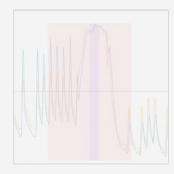




Small Satellite Data Science

AnalyThank You!

EXCALIBUR Exoplanet Classifier



Telemanom Anomaly Detection a b CL 4 0 DSS-26
DSS-34
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Aug 27
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Aug 29



MAARS Image Captioning

