



Make Planetary Images Searchable: Content-based search for PDS and On-Board Datasets

Masahiro Ono¹, Brandon Rothrock¹, Chris Mattmann¹, Tanvir Islam¹, Annie Didier¹,
Vivian Z. Sun¹, Dicong Qiu², Paul Ramirez¹, Kevin Grimes¹, Gabrielle Hedrick³, and Chris Laporte¹

¹ Jet Propulsion Laboratory, California Institute of Technology, ² Carnegie Mellon University, ³ West Virginia University

Contact: ono@jpl.nasa.gov

BACKGROUND

UGMP

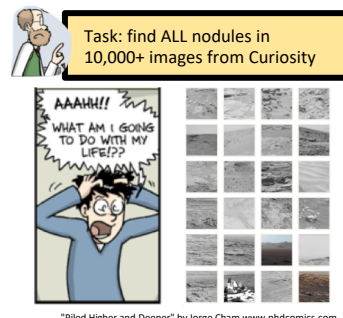
Unnoticed Green Monster Problem



A rover could pass by a green monster (a metaphor for a serendipitous encounter with important scientific features) without being noticed by ground operations because image acquisition is not commanded at that moment or the image of the green monster is simply not downlinked due to the limitation in the communication capacity

GHTMI

Geologist's Headache with Too Many Images

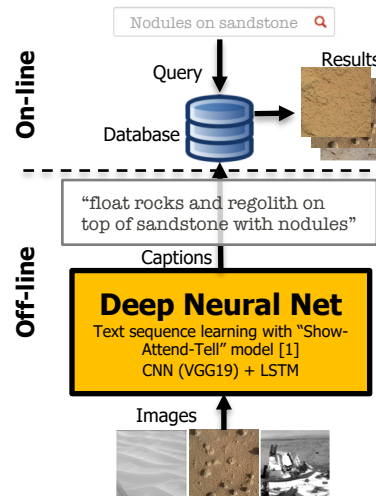


Even with a filtered collection, a geologist will often have to manually eyeball thousands of images on PDS to find subtle features that s/he is researching (e.g., nodules, veins, layers with a particular geometry)

APPROACH

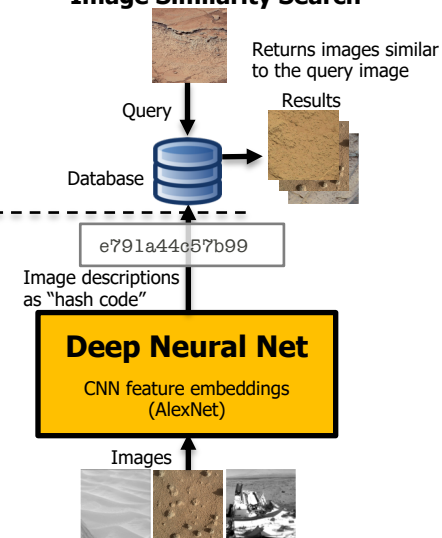
SCOTI

Text-based search on auto-generated image captioning



ImageSpace

Image Similarity Search



USE CASES

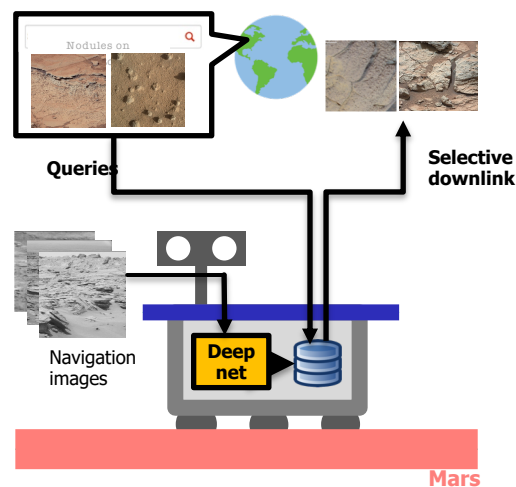
Convert "drive-only" rovers to a scientifically valuable one

Example: The future **Sample Fetch Rover** concept for Mars Sample Return

- No science instruments planned to be accommodated; "drive-only" mission
- Need to take navigation images for every ~1m
- Up to ~1 km/Sol = 1,000 images/Sol
- Has bandwidth limitation; may not be able to send all images

How SCOTI/ImageSpace can help:

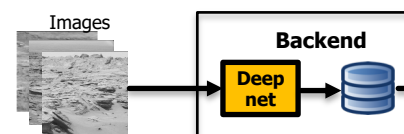
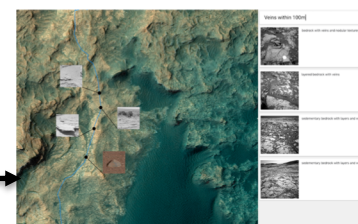
- Index *all* images on-board
 - Generate captions/hash code
- Ground scientists specify features of interest by text or sample images
- Rover selectively returns data relevant to the query
- Deep net is feasible to run on-board with HPSC



Make PDS images searchable

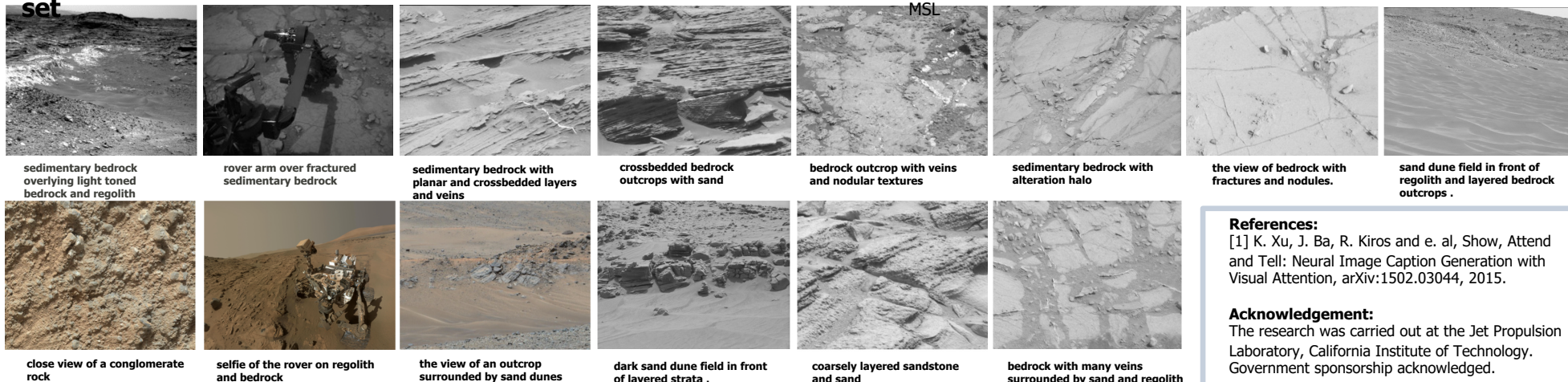
Proposed plan:

- All MSL images on PDS are preprocessed and indexed by SCOTI and ImageSpace
- Users can search images by text or image similarity
- Geospatial user interface currently being developed
- Collect training data through PDS to improve performance
- Prototype release in April (internal to JPL)
- Public release TBD



RESULTS

Auto-generated image captions by SCOTI on validation set



- Network trained with ~3,000 annotated images created by a geologist
- Training & validation sets contain NAVCAM and MASTCAM images from MSL

References:

[1] K. Xu, J. Ba, R. Kiros and e. al, Show, Attend and Tell: Neural Image Caption Generation with Visual Attention, arXiv:1502.03044, 2015.

Acknowledgement:

The research was carried out at the Jet Propulsion Laboratory, California Institute of Technology. Government sponsorship acknowledged.