

MOON TREK TELESCOPE

California State University Los Angeles
Sponsor: Jet Propulsion Lab
Spring 2021



TEAM MEMBERS AND ROLES



NICOLAS OJEDA

Team Lead
Backend (django) ,
Graphics(Threejs)



ALEX LAMB

Communications Lead



ALBERT RAMIREZ

Lead Backend Developer



DAKOTA TOWNSEND

Documentation Lead



JACOB FRAUSTO

QA/Testing Lead



KEVIN AGUILERA

Development
(Graphics Model)



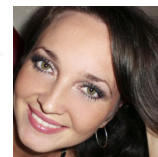
GERARD ROSARIO

Front End Graphics
Lead



PAVIT CHAWLA

User Interface Lead



ELVIRA SAKALENKA

Computer Vision Lead

LIAISONS



SHAN MALHOTRA



Jet Propulsion Laboratory
California Institute of Technology

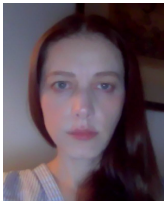


NATALIE GALLEGOS



Jet Propulsion Laboratory
California Institute of Technology

FACULTY ADVISOR



WERONIKA CWIR

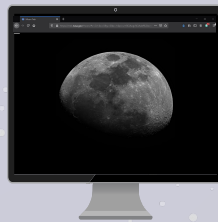


AGENDA

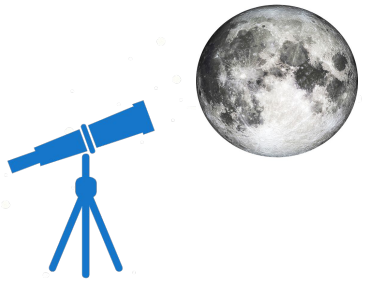
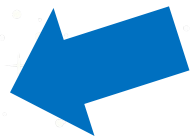
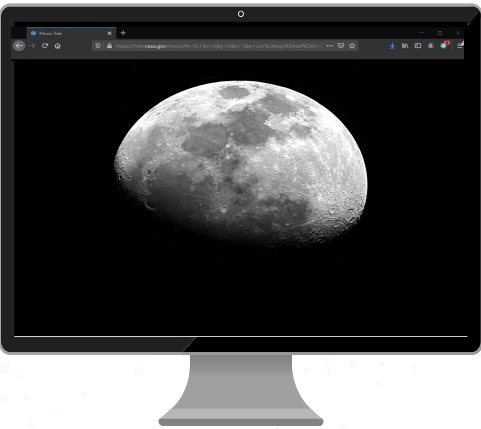
1. OVERVIEW
2. MAJOR REQUIREMENTS
3. PROJECT TECHNOLOGIES
4. GENERAL APPROACH
5. PROJECT CHALLENGES & SOLUTIONS
6. DEMO

overview

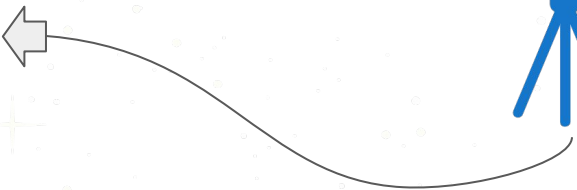
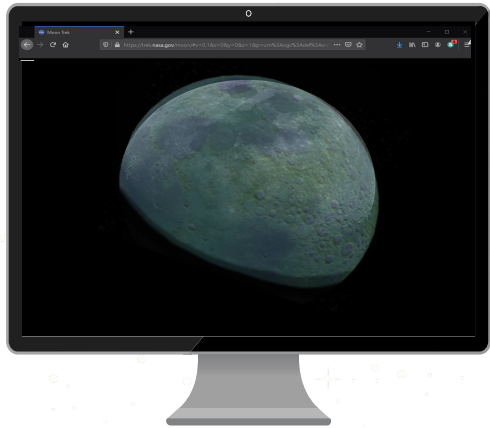
- Stream from telescope to web app
- Fetch data from JPL's Moon Trek
- Apply data to user's image



MOON TREK TELESCOPE | OVERVIEW

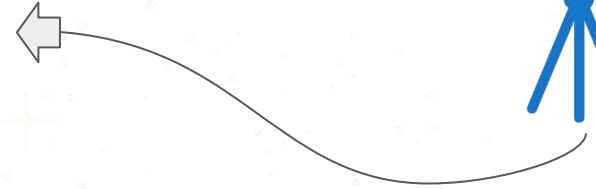
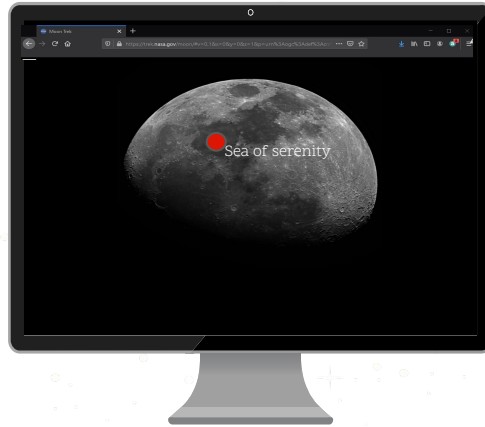
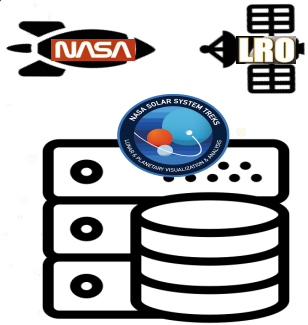


MOON TREK TELESCOPE | OVERVIEW



Feature:
Image captured with user's
telescope with elevation overlay

MOON TREK TELESCOPE | OVERVIEW

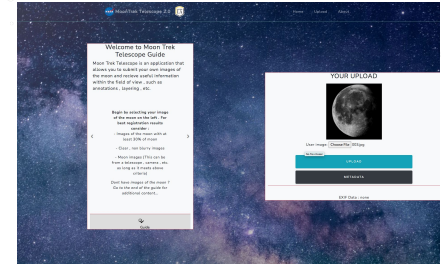


Feature:
Image captured with user's
telescope with annotation of
craters , etc.

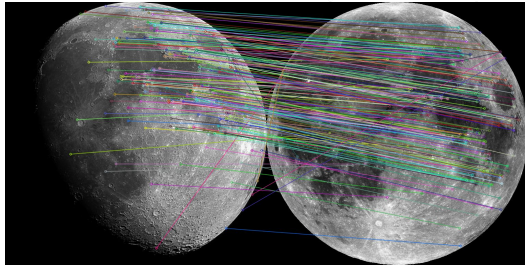
Major requirements

MOON TREK TELESCOPE | MAJOR REQUIREMENTS

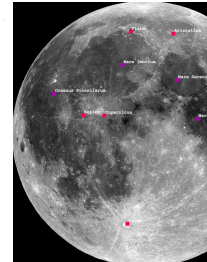
1. Route user's images to web app



2. Register it to mosaic of the Moon

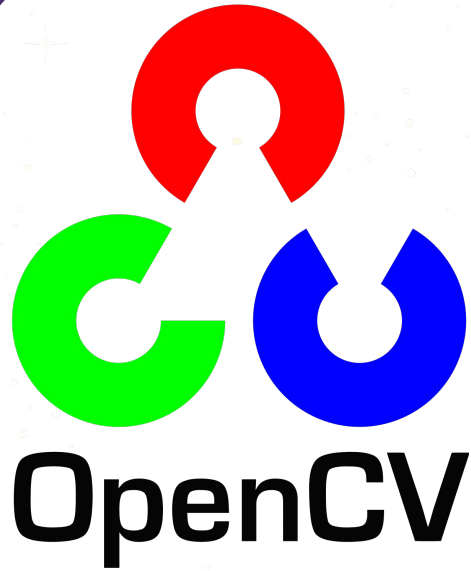


3. Annotate it with data

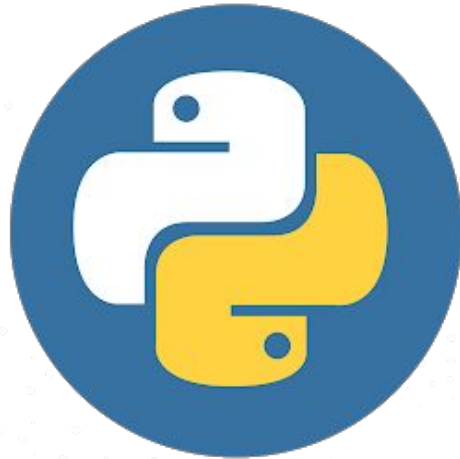


TECHNOLOGIES

TECHNOLOGIES | Backend/Server Side



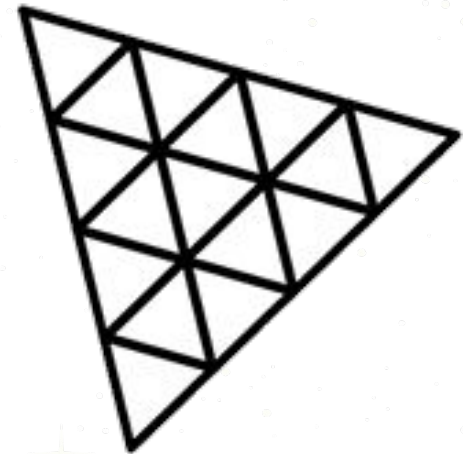
django



Python



TECHNOLOGIES | FRONT-END/CLIENT SIDE

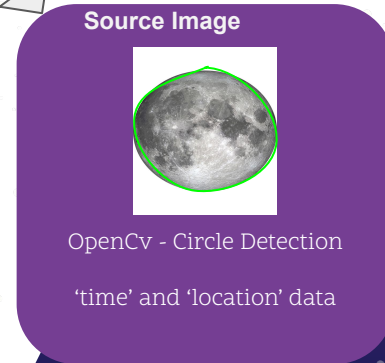
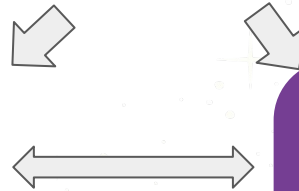
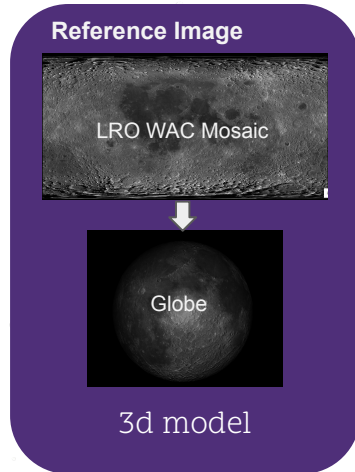
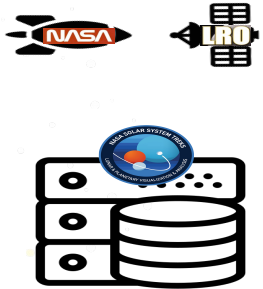


three.js

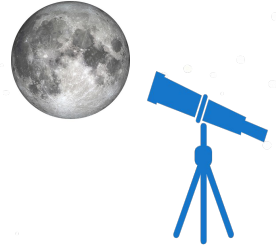
APPROACH

Image registration of source image to a reference image that correctly correlates with the Moon Trek Portal

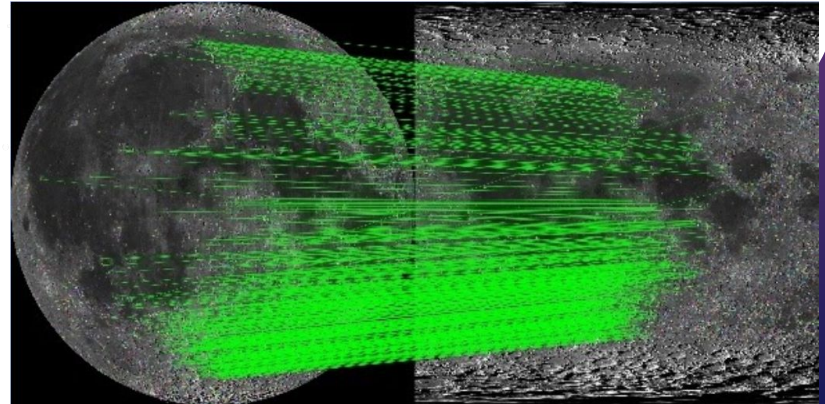
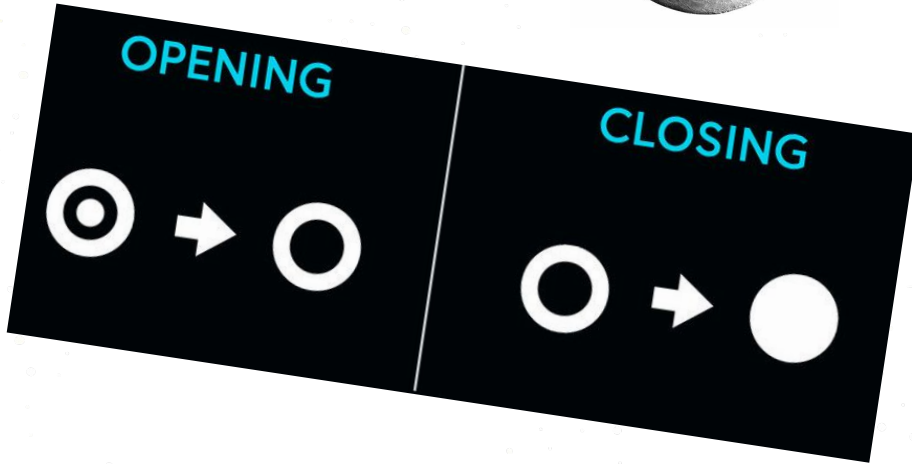
MOON TREK TELESCOPE | APPROACH



Goal is to exactly map the source view in the reference image .



MOON TREK TELESCOPE | APPROACH



MOON TREK TELESCOPE | APPROACH

Request

```
http://54.157.167.17:5000/nearest-point/earth/moon/-118.173225/34.195109/2020-10-07T01:10:45
```

Response

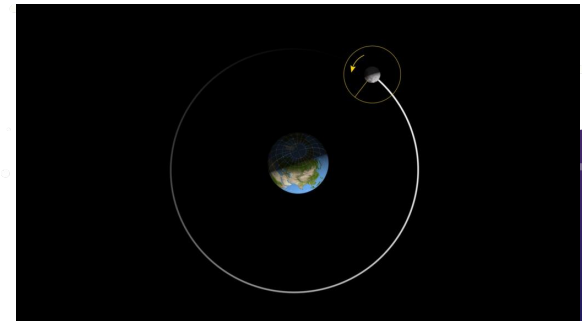
```
{  
  "observer": "earth",  
  "target": "moon",  
  "altitude_km": 1737.4,  
  "longitude": -4.551454259598997,  
}
```

Request

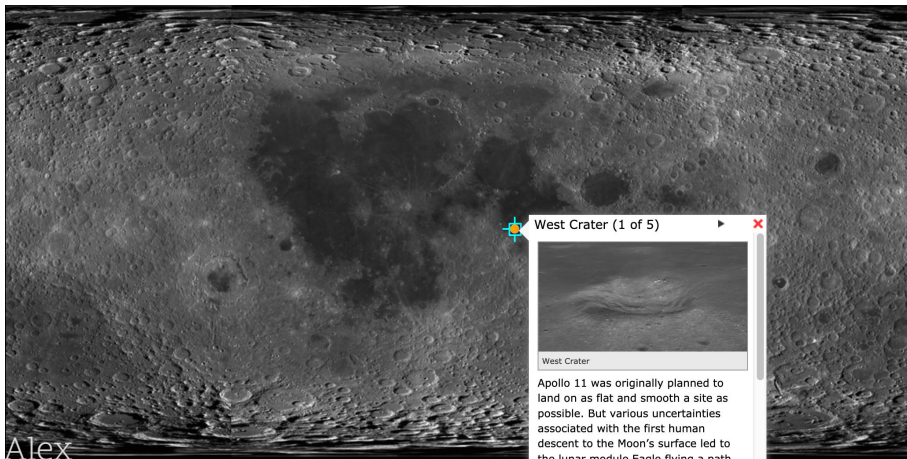
```
http://54.157.167.17:5000/lat-to-rect/moon/earth/0/0/2019-10-07T01:10:45
```

Response

```
{  
  "origin": "EARTH",  
  "units": "km",  
  "positions": {  
    "moon": {  
      "x": -12282.268170093246,  
      "y": -368872.8597873927,  
      "z": -147150.61159076623  
    }  
  }  
}
```



MOON TREK TELESCOPE | APPROACH



- Determine what is moon in source image
- Perform morphological transformations on source image
- Register source image with reference image
- Produce faithful longitude/latitude coordinates for source image
- Apply data layers to source image



CHALLENGES/SOLUTIONS

CHALLENGES/SOLUTIONS | CIRCLE DETECTION

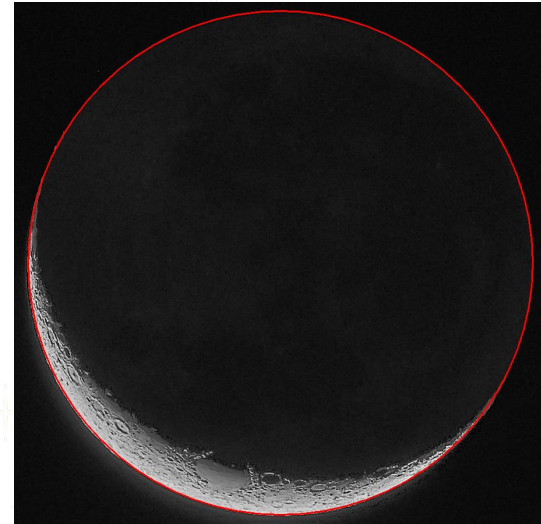
- OpenCV HoughCircles()
- Accuracy
- Optimization

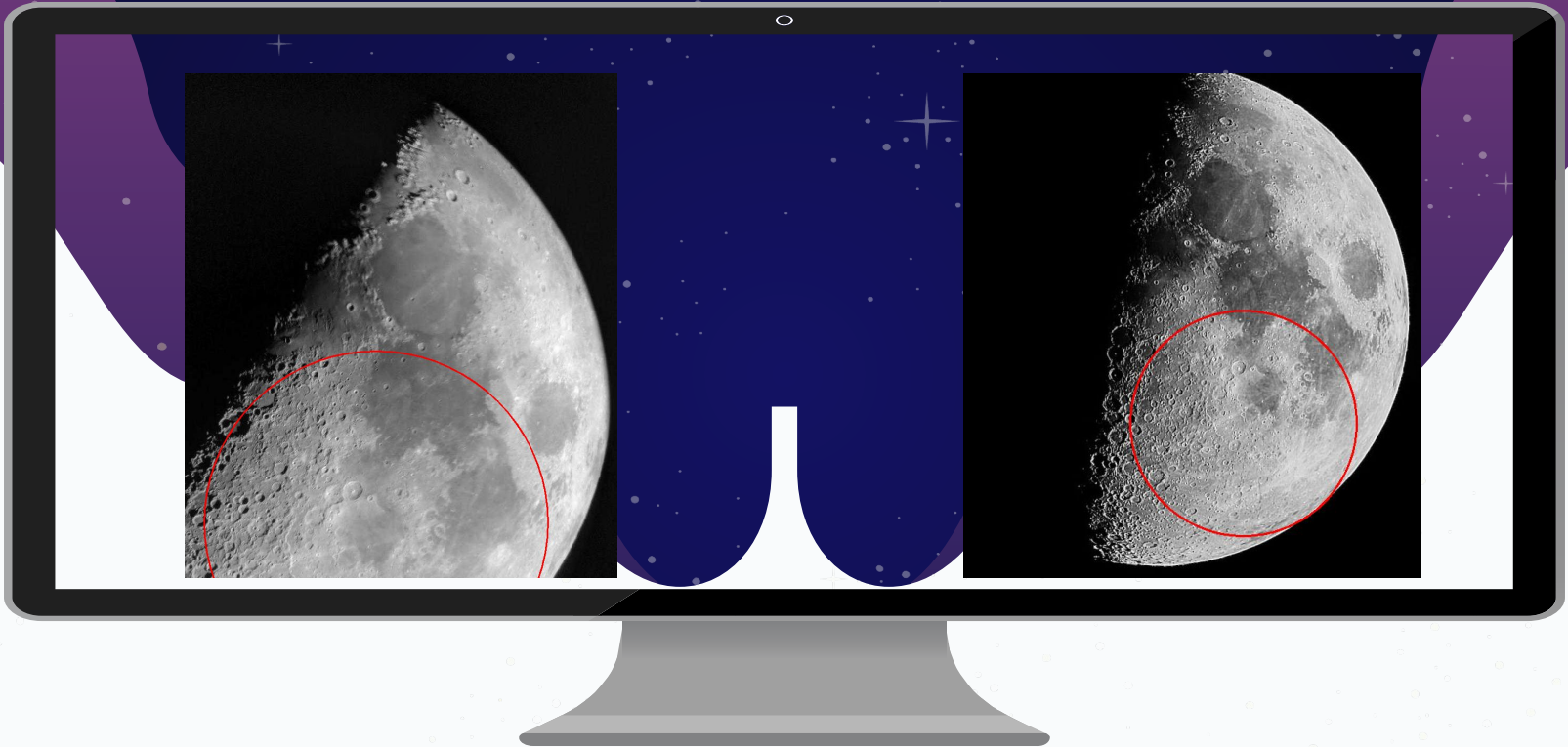


CIRCLE DETECTION CHALLENGES

OpenCV HoughCircles()

- **image:** image for circle detection
- **detection method:** HOUGH_GRADIENT - method for circle detection
- **dp :** inverse ratio of resolution
- **min_dist:** minimum distance between detected centers
- **param_1:** Upper threshold for the internal canny edge detector
- **param_2:** Threshold for center detection
- **min_radius:** (unused) Minimum radius to be detected
- **max_radius:** (unused) Maximum radius to be detected





CIRCLE DETECTION ERRORS



CIRCLE DETECTION SUCCESSES

CIRCLE DETECTION CHALLENGES

Optimization

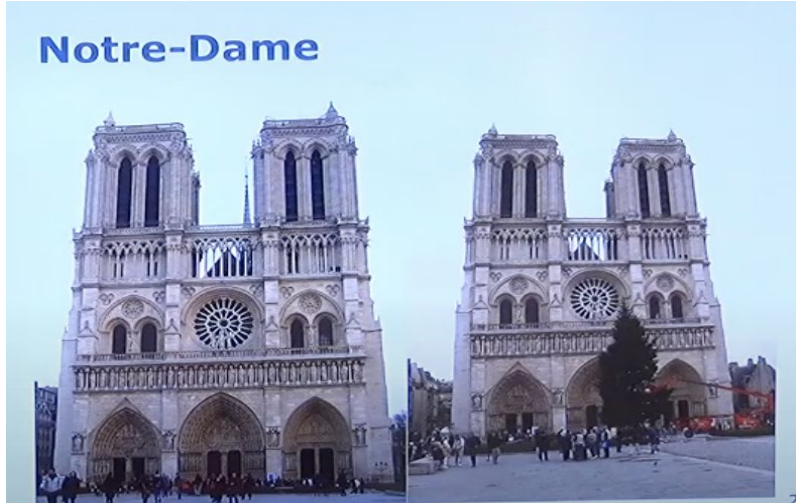
- Experimented with parameter values to increase accuracy
- Successful in decreasing runtime



CHALLENGES/SOLUTIONS | image registration

Image registration is an image processing technique which transforming different set of data (multiple photographs, data from different sensors, times, depths, or viewpoints) into one coordinate system.

Example of data:



Notre-Dame



User image



Reference image

Image registration | OPENCV(COMP VISION)

Sample of 108 images and our challenges :



- ORB (Oriented FAST and Rotated BRIEF)
- SIFT (Scale Invariant Feature Transform)
- BRISK (Binary Robust Invariant Scalable Keypoints)
- SURF (Speeded-up Robust Features)

Image registration | SIFT (Scale Invariant Feature Transform) Feature Transform

General stages of automatic image registration:

- Feature detection and description

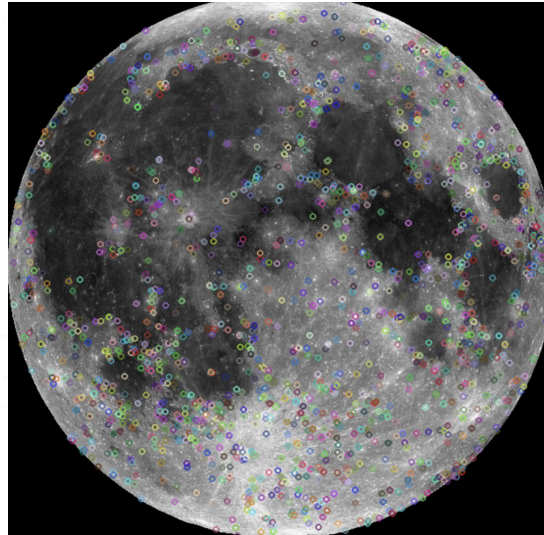
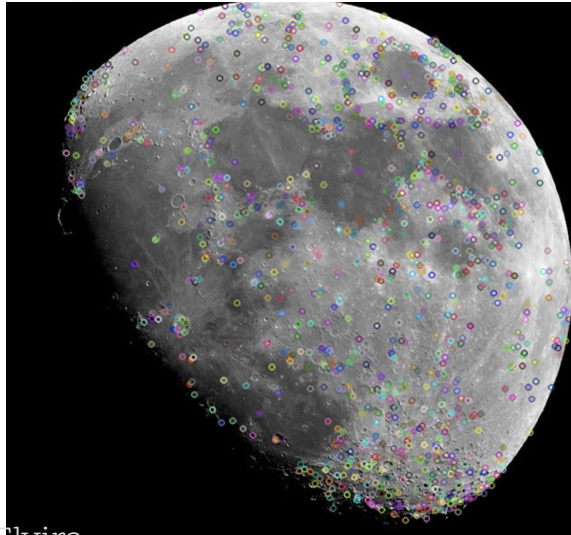


Image registration | SIFT (Scale Invariant Feature Transform) Feature transform

- Feature matching

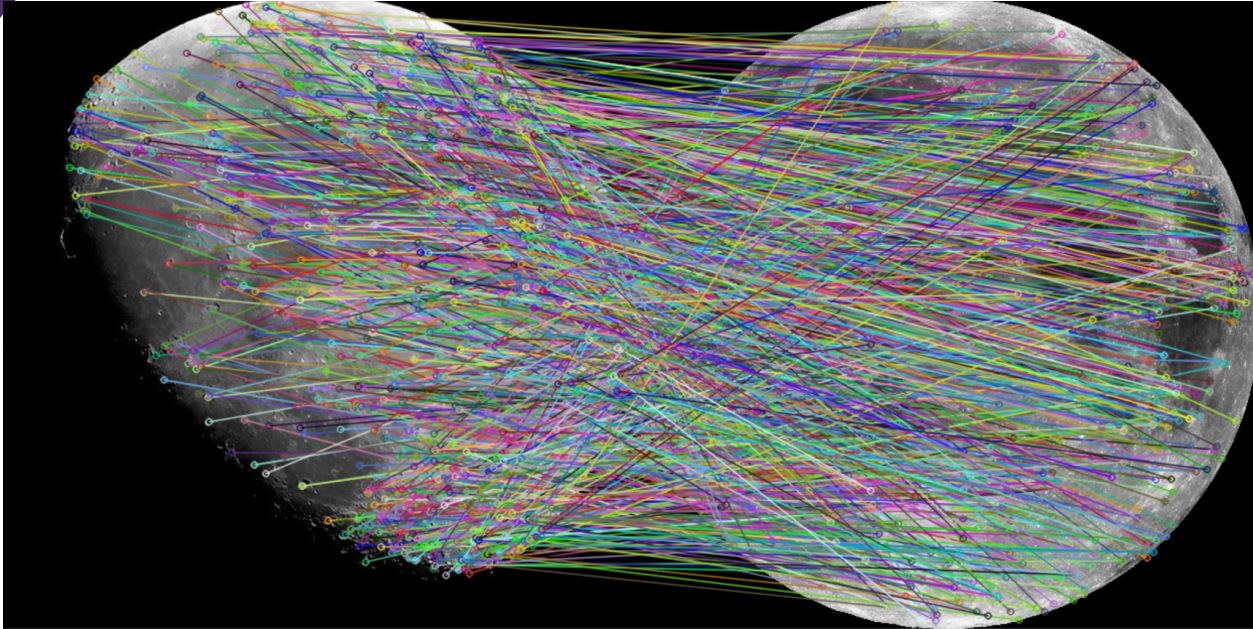


Image registration | SIFT(Scale Invariant Feature Transform) Feature Transform

- Outlier rejection(The RANSAC - Random Sample Consensus)

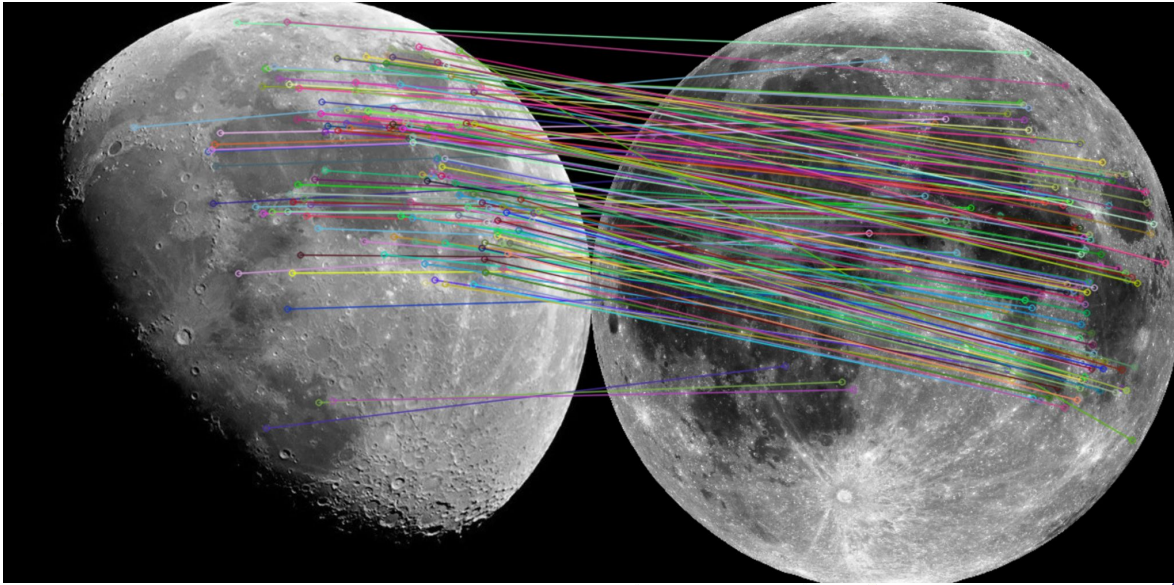


Image registration | SIFT (Scale Invariant Feature Transform) Feature Transform

- Derivation of transformation function
- Image reconstruction



Image registration | SIFT (Scale Invariant Feature Transform) Feature Transform

Results:

About 30 % images failed

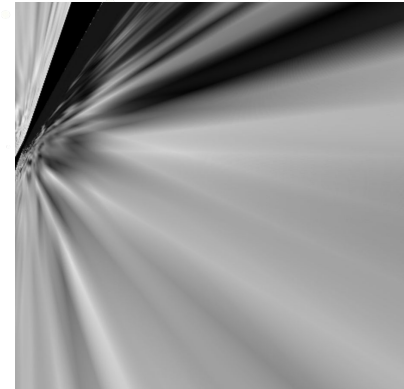
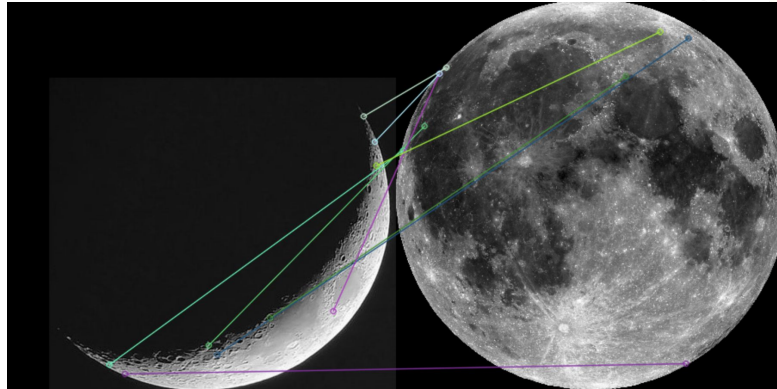
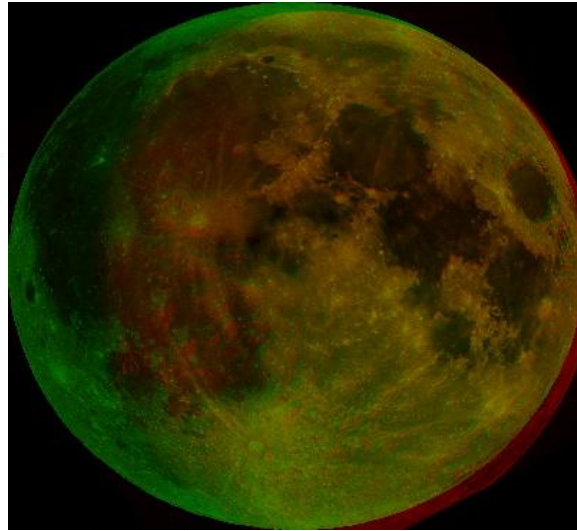
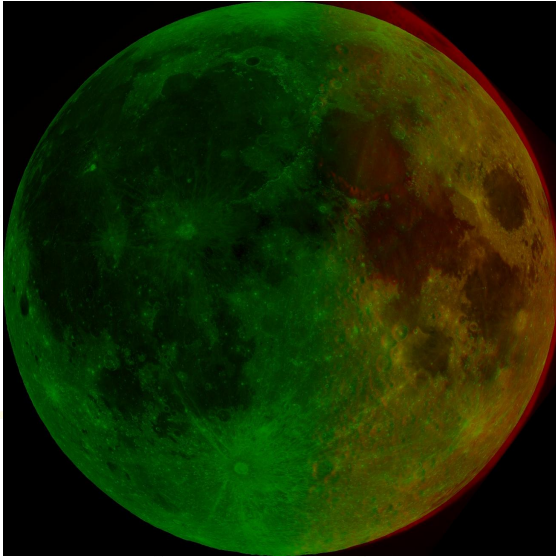


Image registration | SIFT (Scale Invariant Feature Transform) Feature Transform

About 70% successful image registration



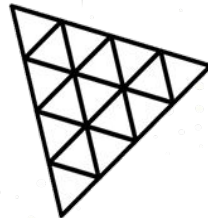
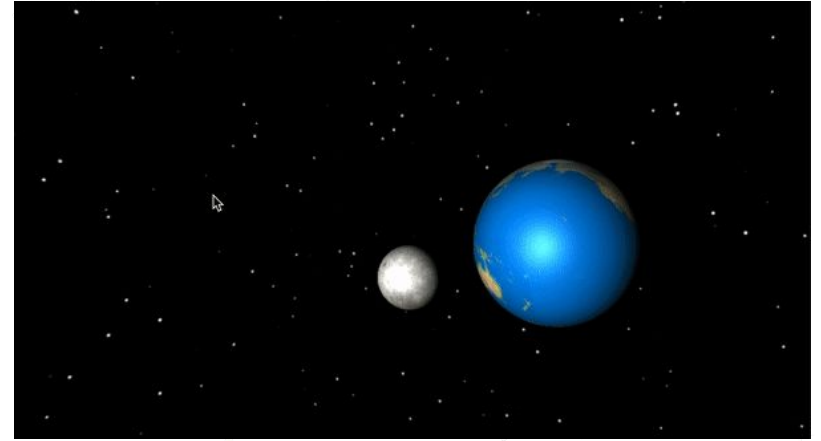
CHALLENGES/SOLUTIONS | 3D MODEL PURPOSE

- Match telescope view with 3D model
- To help calculate nearest point of what's visible through telescope
- Important for image registration



CHALLENGES/SOLUTIONS | 3D MODEL CHALLENGES

- Original 3D model plans
 - Lunar phase : Shape of the Moon due to sunlight
- Three.js
 - New language
 - Complex understanding



three.js

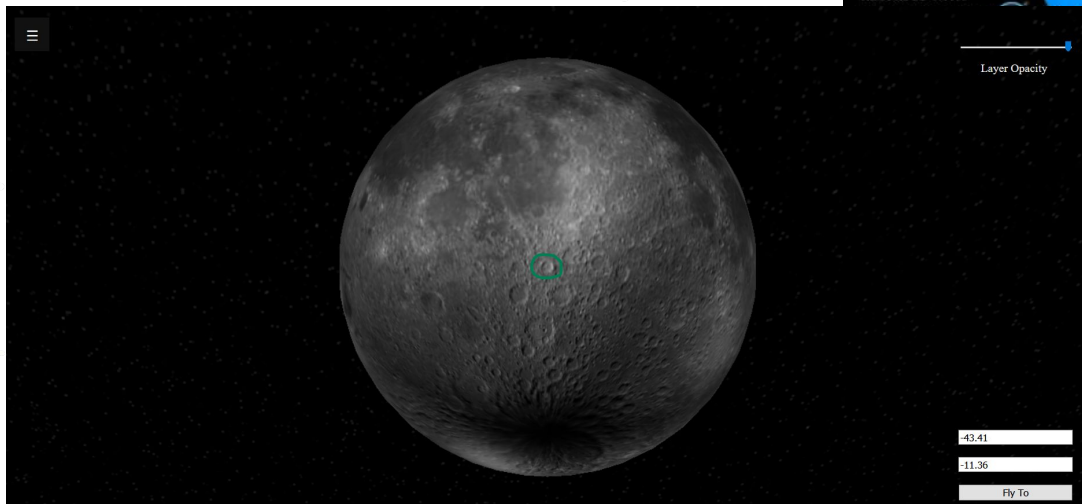
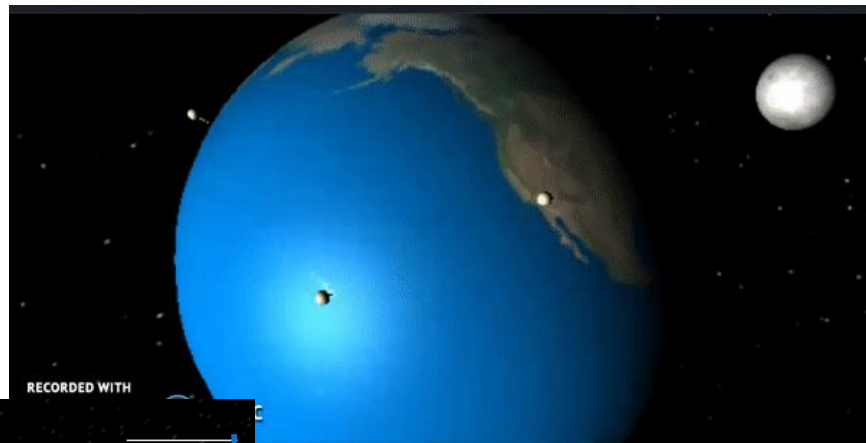
CHALLENGES/SOLUTIONS | 3D MODEL CHANGES

- Suitable substitute for the 3D model
- Use of existing image of the Moon called the Globe LRO REF
- New 3D model with user experience



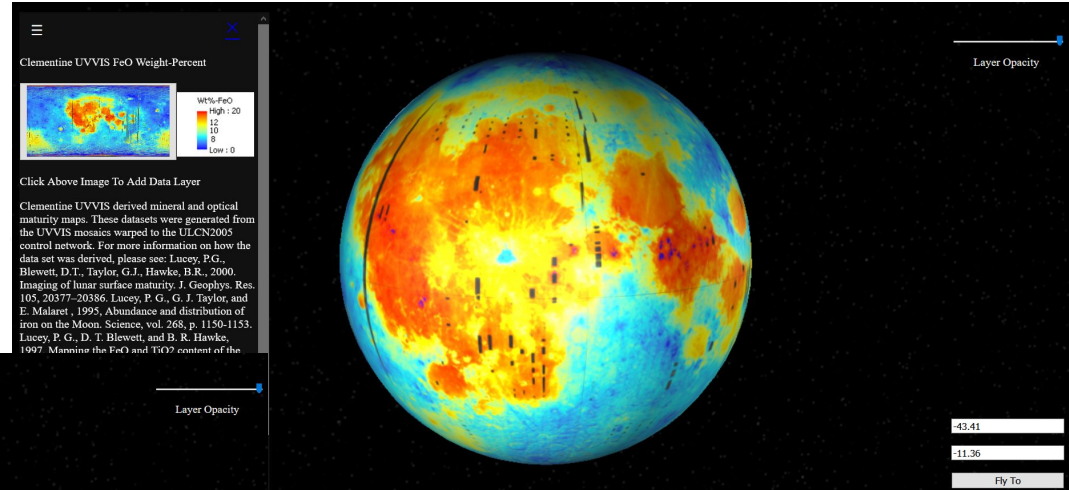
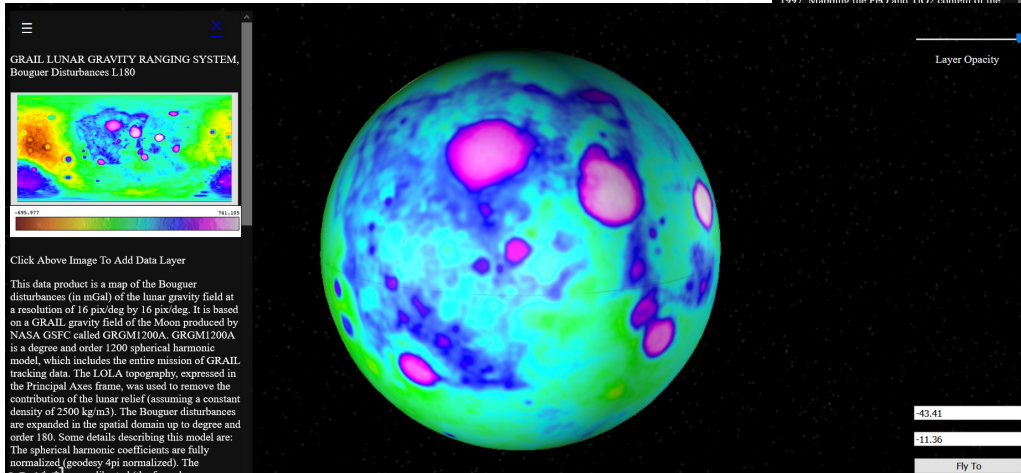
CHALLENGES/SOLUTIONS | 3D MODEL FLY TO

- Points on sphere
- For accuracy
- Original function
 - New function.



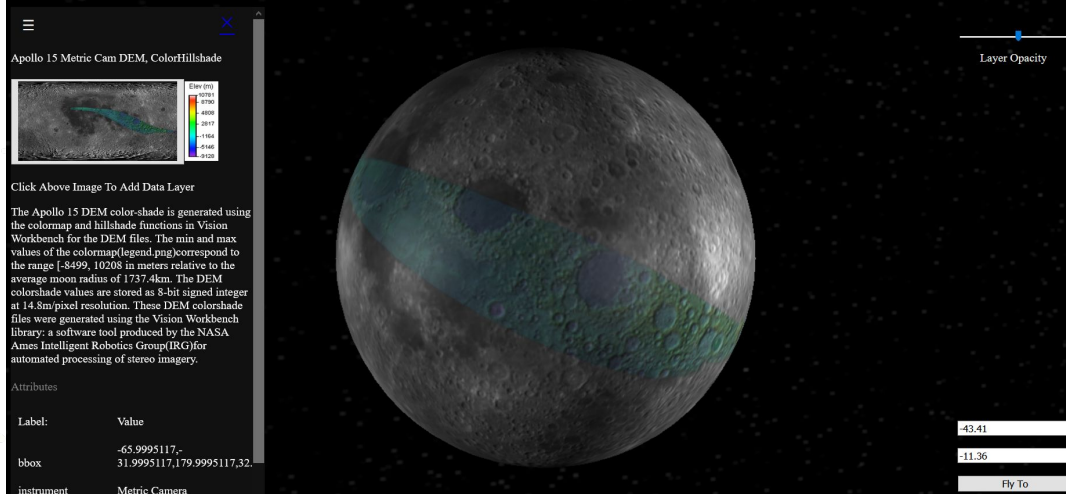
CHALLENGES/SOLUTIONS | 3D MODEL LAYERS

- Adding annotations
- User Interaction
- Implementation with OpenLayers
 - With Threejs



CHALLENGES/SOLUTIONS | 3D MODEL OPACITY

- A way to check the annotation
- Level can be designated
- Implementation in OpenLayer



A screenshot of a 3D lunar model interface. The main view shows a 3D model of the Moon with a semi-transparent layer overlaid, representing the Apollo 15 Metric Cam DEM. The interface includes a legend for the data layer, a 'Layer Opacity' slider, and a 'Fly To' input field.

Apollo 15 Metric Cam DEM, ColorHillshade

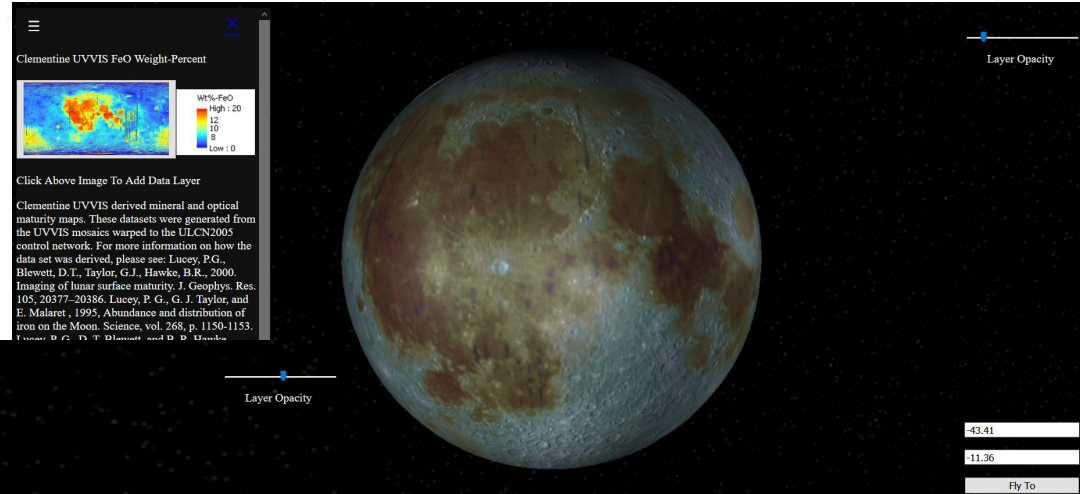
Click Above Image To Add Data Layer

The Apollo 15 DEM color-shade is generated using the colormap and hillshade functions in Vision Workbench for the DEM files. The min and max values of the colormap/legend.pug correspond to the range [-8499, 10208] in meters relative to the average moon radius of 1737.4km. The DEM colorshade values are stored as 8-bit signed integer at 14.8m/pixel resolution. These DEM colorshade files were generated using the Vision Workbench library: a software tool produced by the NASA Ames Intelligent Robotics Group(IRG)for automated processing of stereo imagery.

Attributes

Label:	Value
bbox	-65.9995117, -31.9995117, 179.9995117, 32.
instrument	Metric Camera

Layer Opacity: -43.41, -11.36, Fly To



A screenshot of a 3D lunar model interface. The main view shows a 3D model of the Moon with a semi-transparent layer overlaid, representing the Clementine UVVIS FeO Weight-Percent data. The interface includes a legend for the data layer, a 'Layer Opacity' slider, and a 'Fly To' input field.

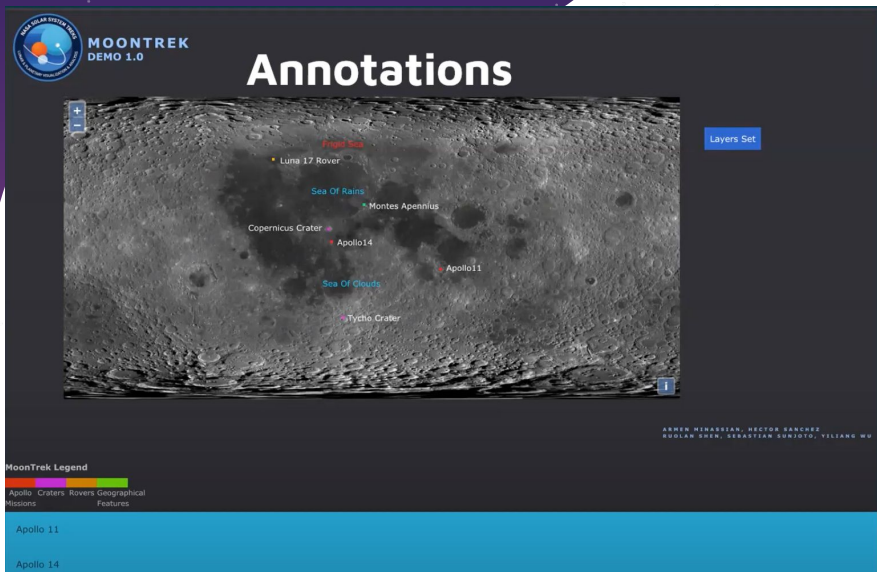
Clementine UVVIS FeO Weight-Percent

Click Above Image To Add Data Layer

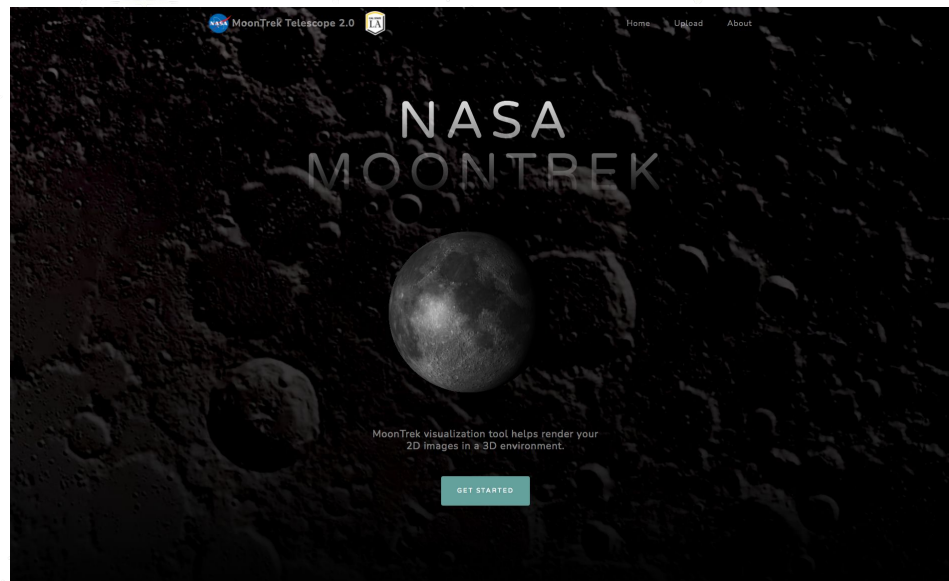
Clementine UVVIS derived mineral and optical maturity maps. These datasets were generated from the UVVIS mosaics warped to the ULCN2005 control network. For more information on how the data set was derived please see: Lucey, P.G., Blewett, D.T., Taylor, G.J., Hawke, B.R., 2000. Imaging of lunar surface maturity. J. Geophys. Res. 105, 20377-20386. Lucey, P. G., G. J. Taylor, and E. Malaret, 1995. Abundance and distribution of iron on the Moon. Science, vol. 268, p. 1150-1153. Figure D. C. D. © Blewett and D. D. Hawke

Layer Opacity: -43.41, -11.36, Fly To

CHALLENGES/SOLUTIONS | NEW INTERFACE

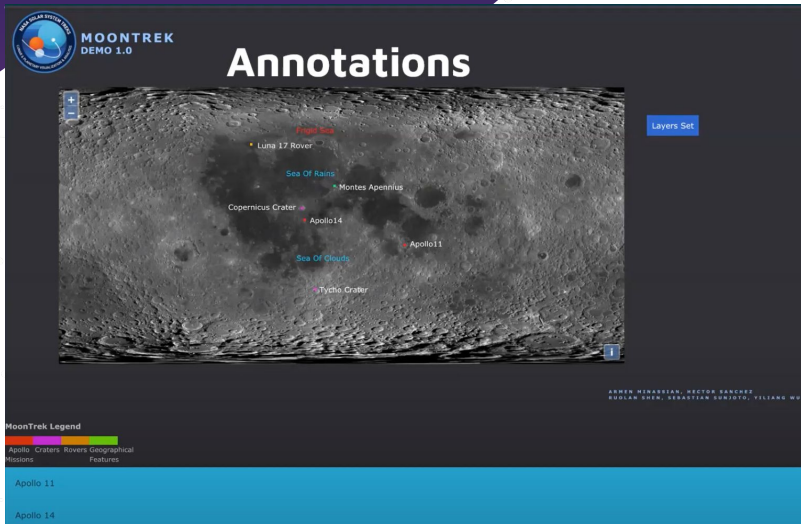


OLD: not straightforward,
What do you do to
begin?

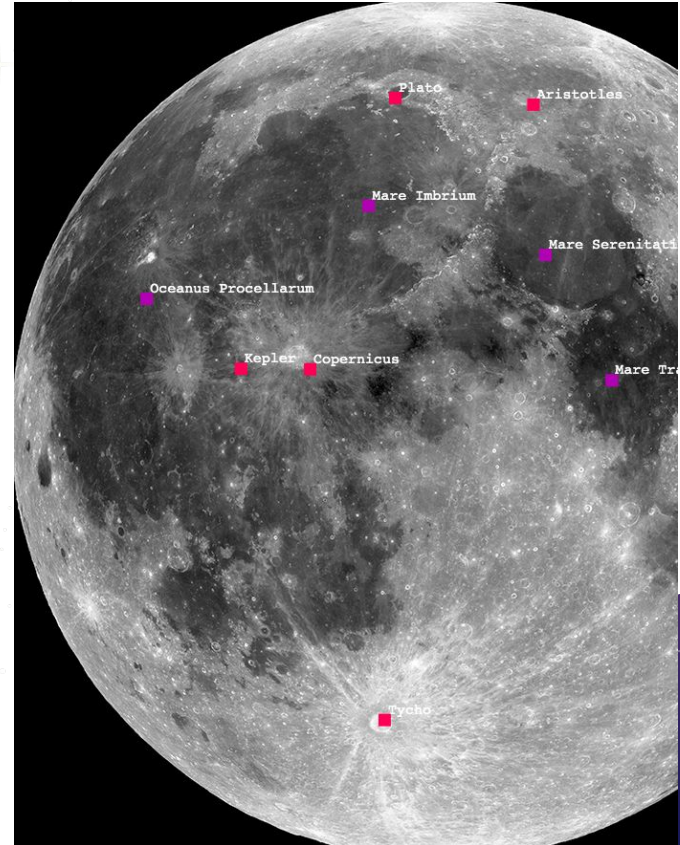


NEW:
More intuitive
Cleaner
Sleeker

UI | REGISTRATION & ANNOTATIONS



OLD



NEW

Welcome to Moon Trek Telescope Guide

Moon Trek Telescope is an application that allows you to submit your own images of the moon and receive useful information within the field of view, such as annotations, layering, etc.

Begin by selecting your image of the moon on the left. For best registration results consider:

- Images of the moon with at least 30% of moon
- Clear, non blurry images
- Moon images (This can be from a telescope, camera, etc. as long as it meets above criteria)

*Dont have images of the moon ?
Go to the end of the guide for additional content...*



Guide

YOUR UPLOAD



User image: 003.jpg

No file chosen

UPLOAD

METADATA

EXIF Data : none

The screenshot displays the MoonTrek Telescope 2.0 interface. On the left is a sidebar menu with the following items: 'CRATERS1' (red), 'MARES1' (teal), 'LANDING SITES1', 'Latitude and Longitude', 'Craters', 'Mares' (highlighted in light blue), 'Mare Serenitatis', 'Mare Crisium', 'Mare Tranquillitatis', 'Mare Imbrium', 'Oceanus Procellarum', and 'Landing Sites'. The main area shows a grayscale image of the Moon with labels and blue square markers for 'Mare Imbrium', 'Mare Serenitatis', 'Oceanus Procellarum', 'Mare Crisium', and 'Mare Tranquillitatis'. At the bottom of the interface is a 'Registration' button.

- Craters
- Landing Sites
- Mares
- Easy to Read Info

- Annotated

Registration

CHALLENGES/SOLUTIONS | USER INTERFACE

- Working with static images
- Simplified version
- Oriented towards a more casual user
- Moving away from a cluttered and complicated interface
- More interactive iteration of MoonTrek



demo