Construction System of Extraterrestrial Crater Dataset: Prototype for Martian Product

Supervisor:

Frontend:

Backend: Hammerouz

Documentation:

for Workshop on 1st Nov.

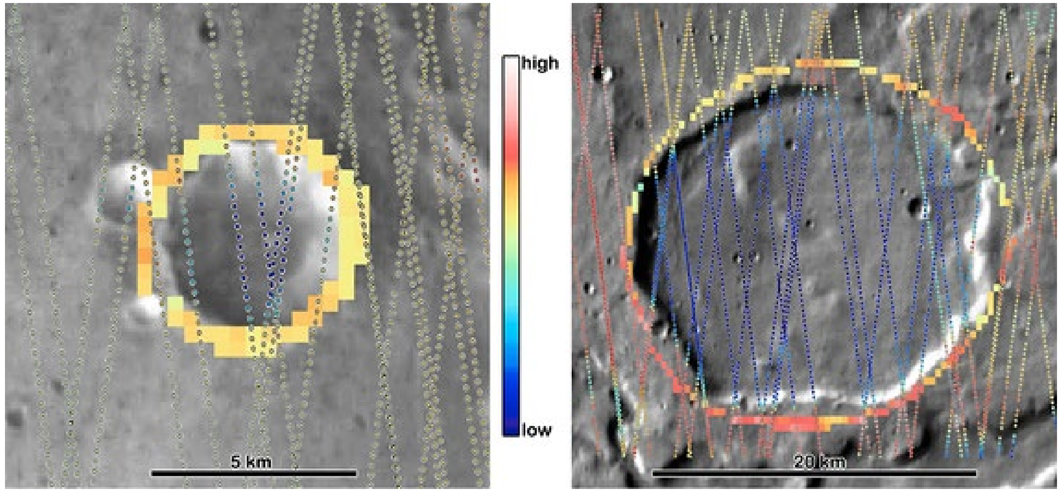
Content

1. Introduction of Previous Research

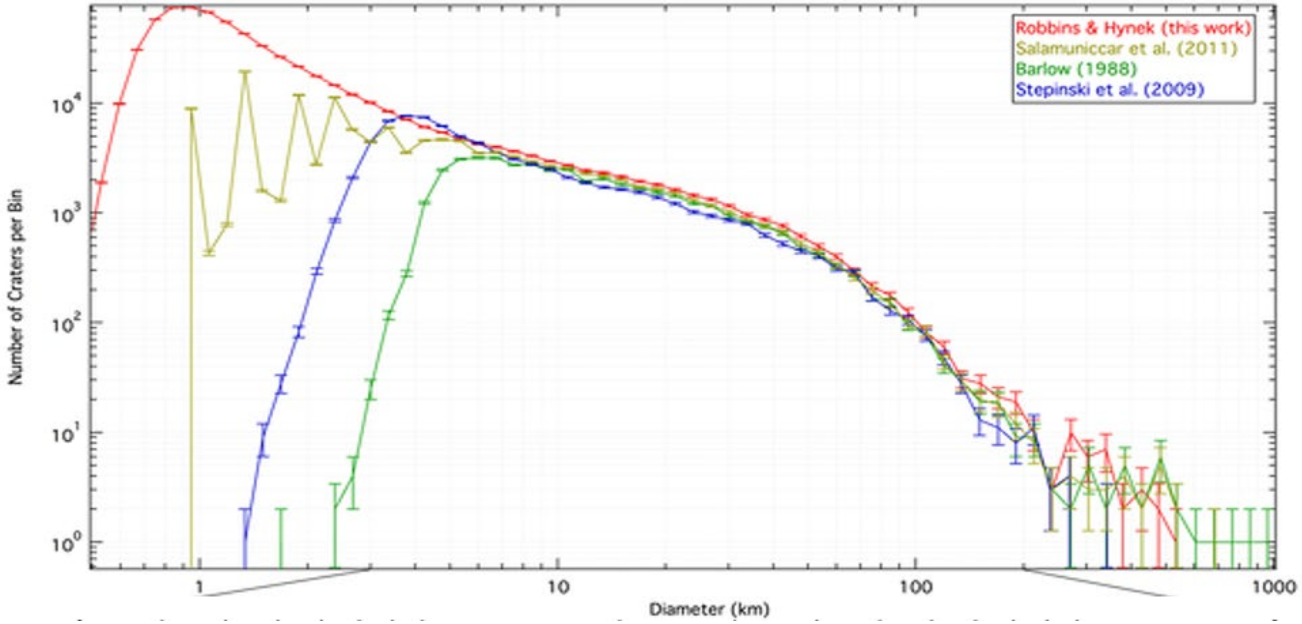
- Data for crater extraction:

  Early stage: High resolution Image data (e.g. Viking, Mariner …)

  With machine learning techniques: MOLA data (Stepinski, 2009)



MOLA's topographic data trails crossing craters



Source & Reference: Robbins J, S,Hynek M B. A new global database of Mars impact craters ≥1 km: 1. Database creation, properties, and parameters[J]. Journal of Geophysical Research: Planets,2012,117(E5).

1. Introduction of Previous Research

Challenges in producing a crater dataset:

- Location Accuracy

(as drifting on small craters)

- Human Error

(introduced from manual operation)

- Extremely heavy workload

(thousands of craters)

- ……

THEMIS Mosaic: 100m/pixel	CTX Mosaic: 5m/pixel

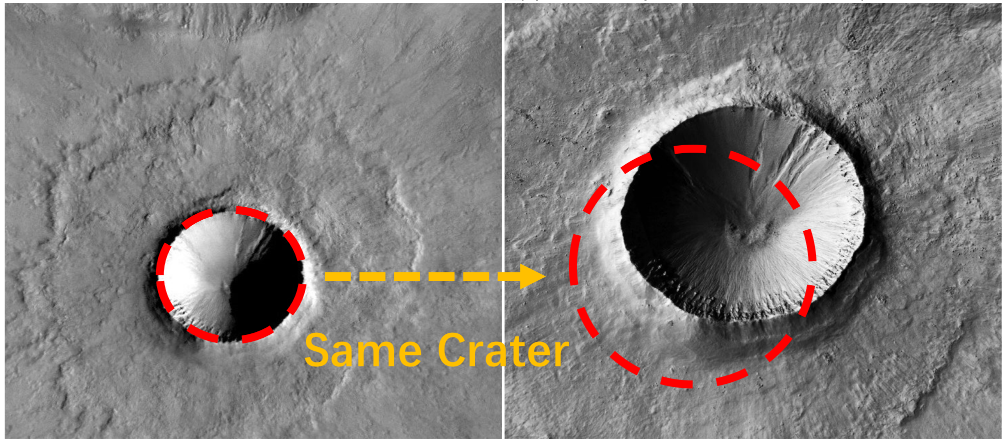
Latitude: -44.3019
Longitude: 139.301
Orbit Number: 66523
Captured: 2016-12-12 09:31
Posted to Web: Tue, 2017-01-31
Instrument: VIS
Image Width: 1024 pixels (17 km)
Image Height: 3648 pixels (61 km)
Vertical Resolution: 0.01691 km/p
Horizontal Resolution: 0.0171037

obbinscraterdatabase_20120821_latlondiam

Lat	Lon_e	Diamkm	Craterid
84.367	108.746	82.10	01-000000
72.760	164.464	82.02	01-000001

查询

Lon_e	Lat	Diamkm	Craterid
139.294	-44.318	3.95	29-003651



Source: https://hirise.lpl.arizona.edu/ESP_027610_2205

2. Detail of Material

Robbins Crater Dataset (2012)

- Refer to THEMIS data @ 100m resolution
- .dbf format

Murray Lab CTX Mosaic Tiles (2023)

- Global coverage (99.5%)
- @ 5m resolution
- .tiff format (4k tiles)

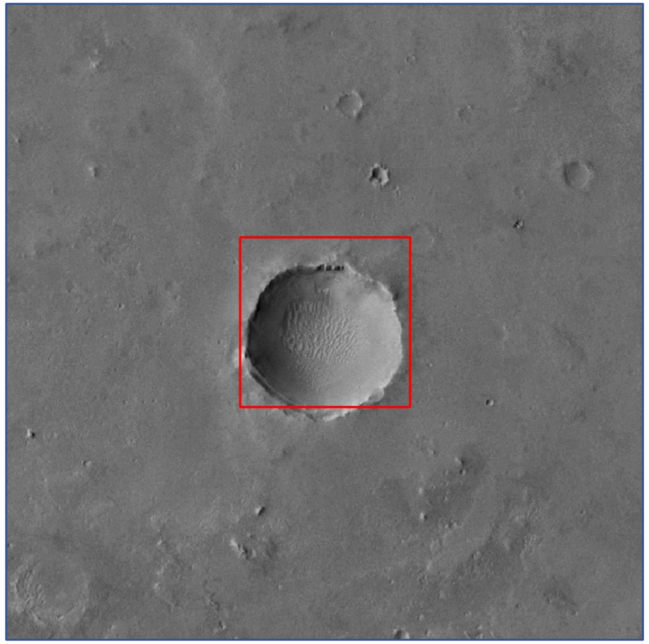
Updated Crater Dataset

Crater Monochrome Tiles @ 5m resolution

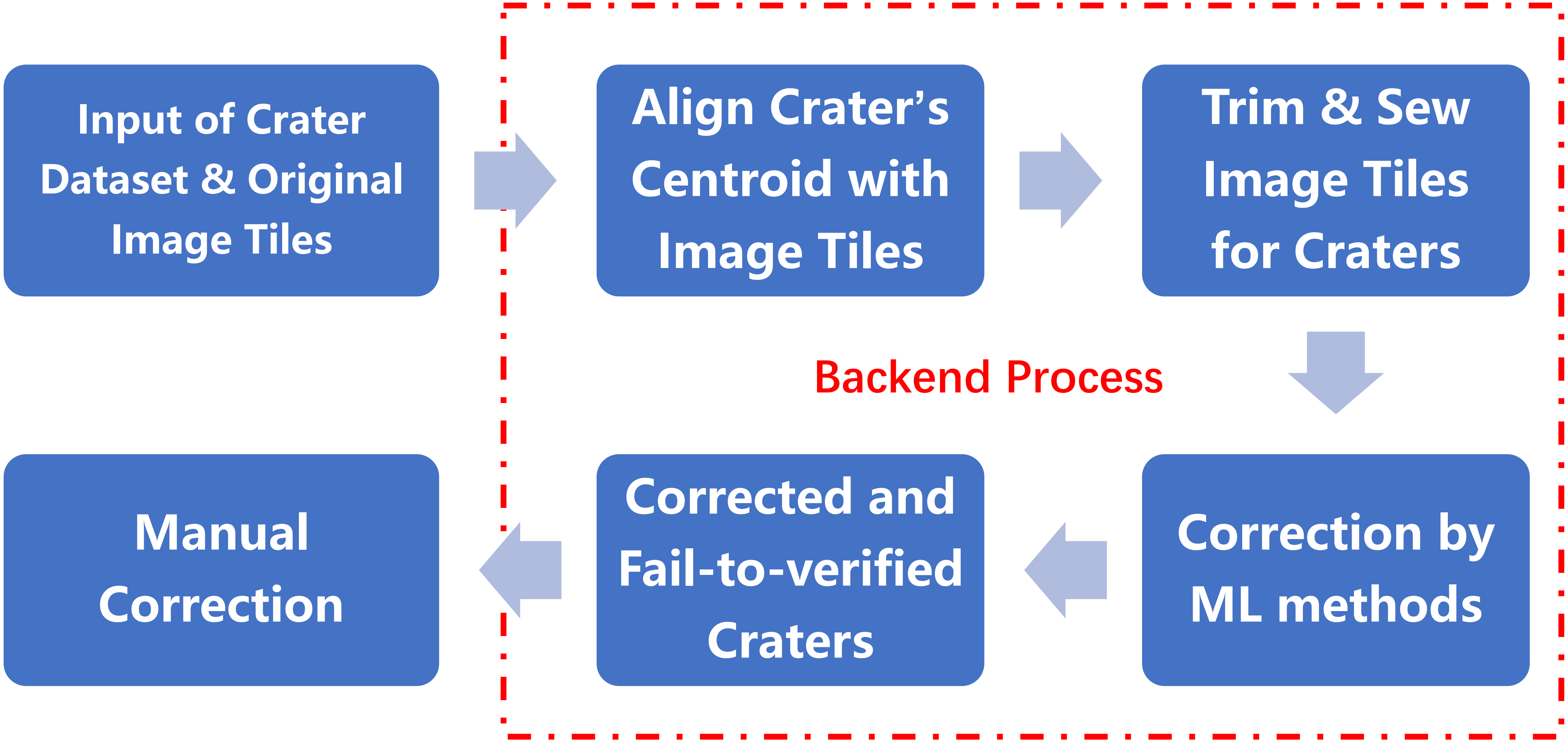
Robbins Crater Dataset

CRATER_ID	LATITUDE_CIRCLE_IMAGE		LONGITUDE_CIRCLE_IMAGE				
01-000000	84.367	108.746	84.75	108.663	82.1	0.26	
01-000001	72.76	164.464	72.784	164.464	82.02	0.09	
01-000002	69.244	-27.24	69.241	-27.235	79.63		84.
01-000003	70.107	160.575	70.151	160.575	74.81	0.05	
01-000004	77.996	95.617	77.998	95.615	73.53	0.23	
01-000005	68.547	137.849	68.551	137.849	72.66		74.

Corresponding Image

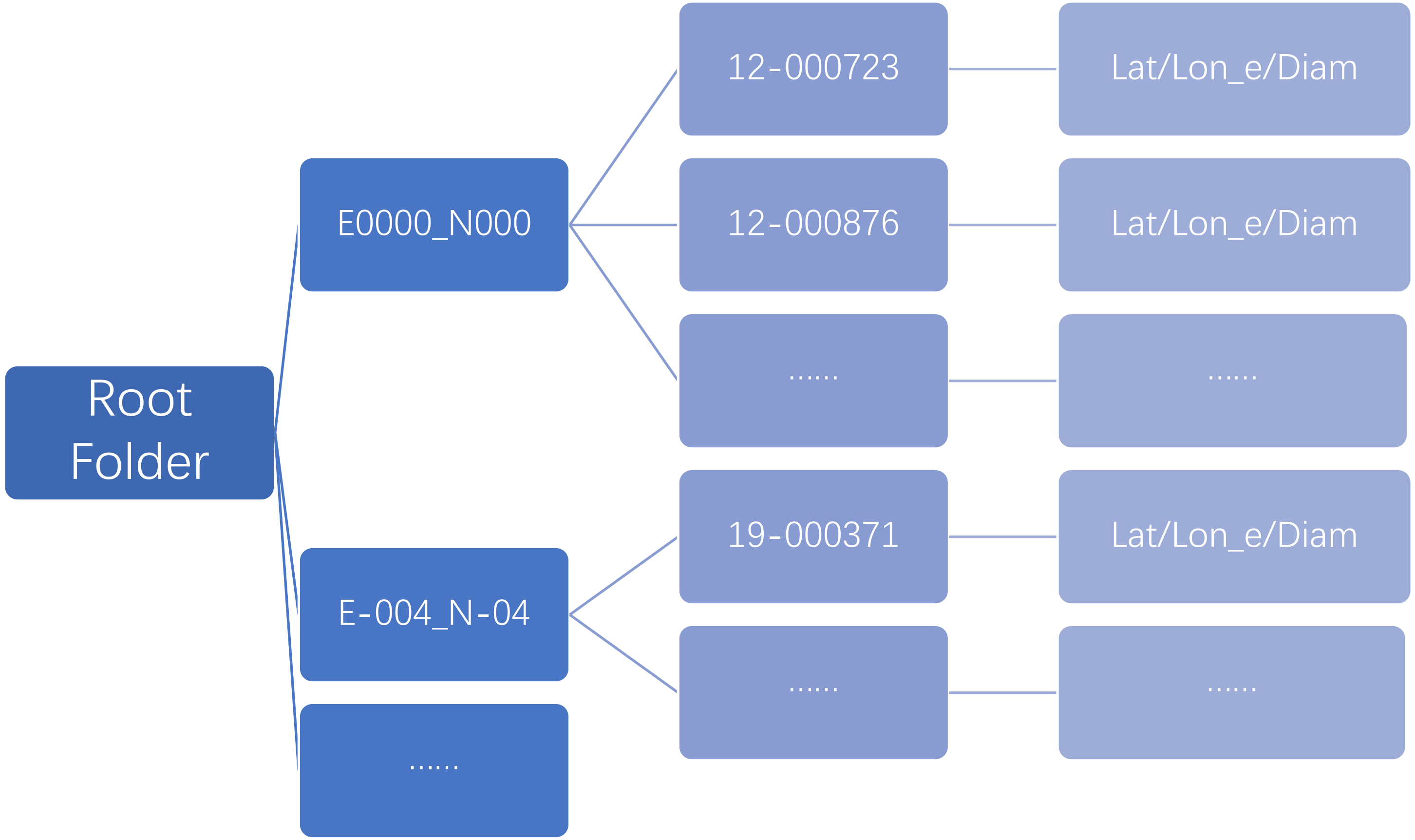


3. Workflow and Implementation



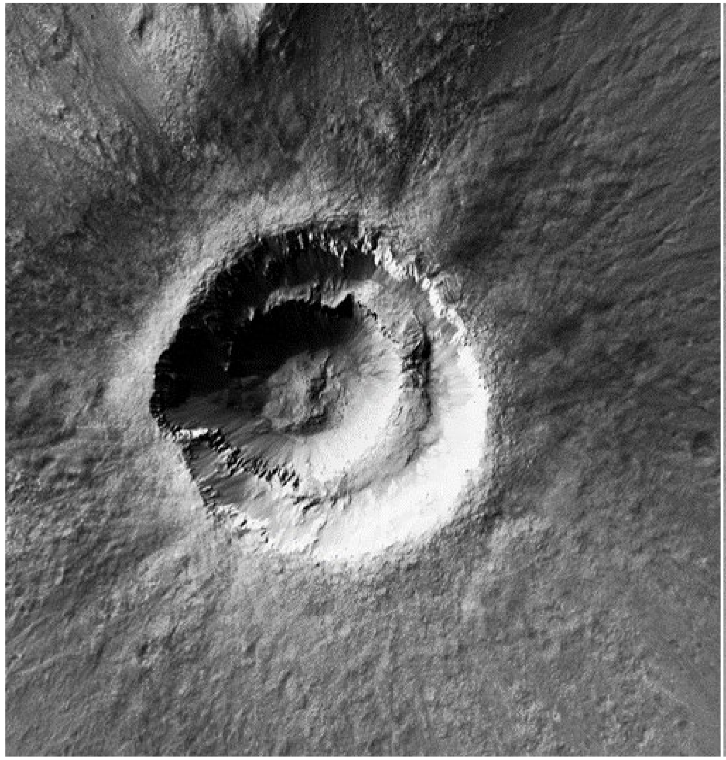
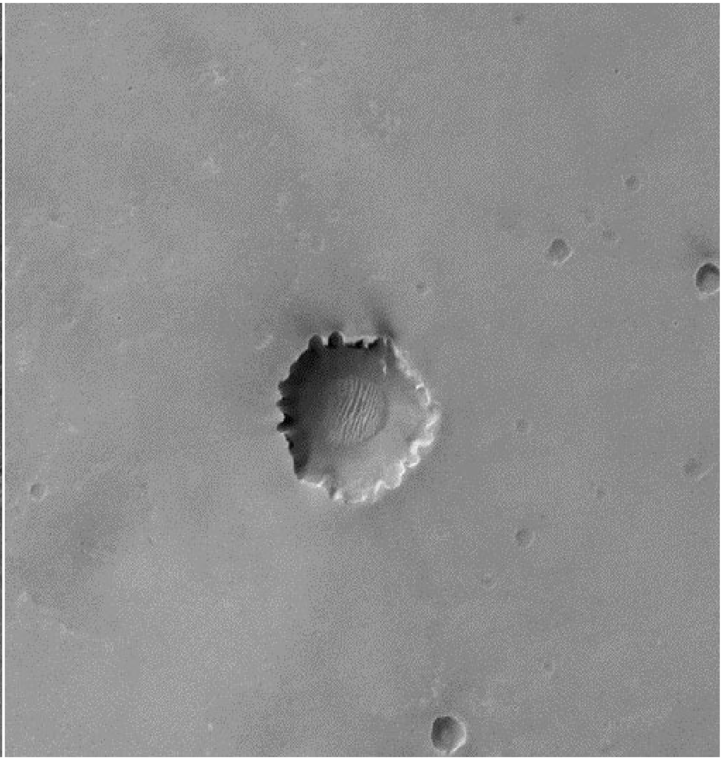
3. Workflow and Implementation

- **Step1: Align Crater's Centroid with Image Tiles**
- Construct file structure in the sequence of "Root Folder - Tile Range – Crater Details"
- Separate craters into folders of tiles according to their referred centroid



3. Workflow and Implementation

- **Step2: Trim & Sew**
- Craters smaller than 1km in radius tend to drift away
- Large Craters: Twice farther than circular radius
- Minimum Spatial Coverage of 4km×4km

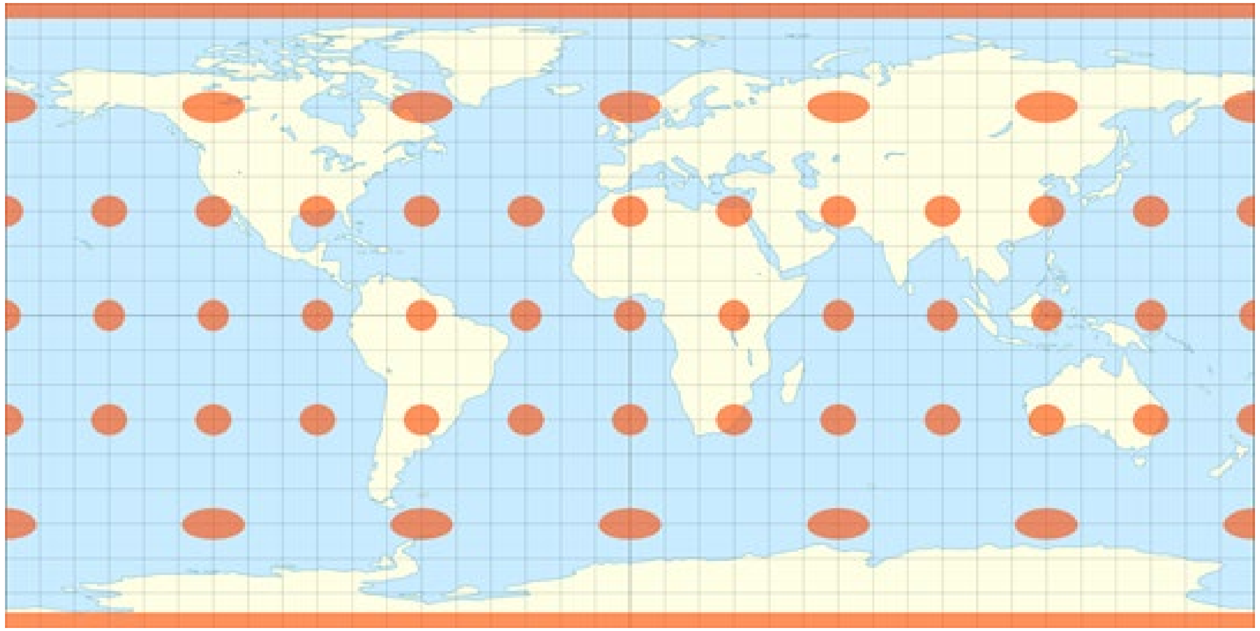
Large Craters (radius > 2km)	Small Craters (radius ≤ 2km)
	

3. Workflow and Implementation

- **Step2: Trim & Sew**
- Large craters intersect with several tiles
- Firstly screen through craters within single tile while marking down intersecting craters
- Then proceed with left-over by "activating" intersecting tiles

3. Workflow and Implementation

- **Note: to correct projection distortion**
- Projection: Equirectangular (equatorial radius 3,396,190 m, polar radius 3,376,200 m)
- Scale and Stretch: Bessel formula for solution of geodetic problem

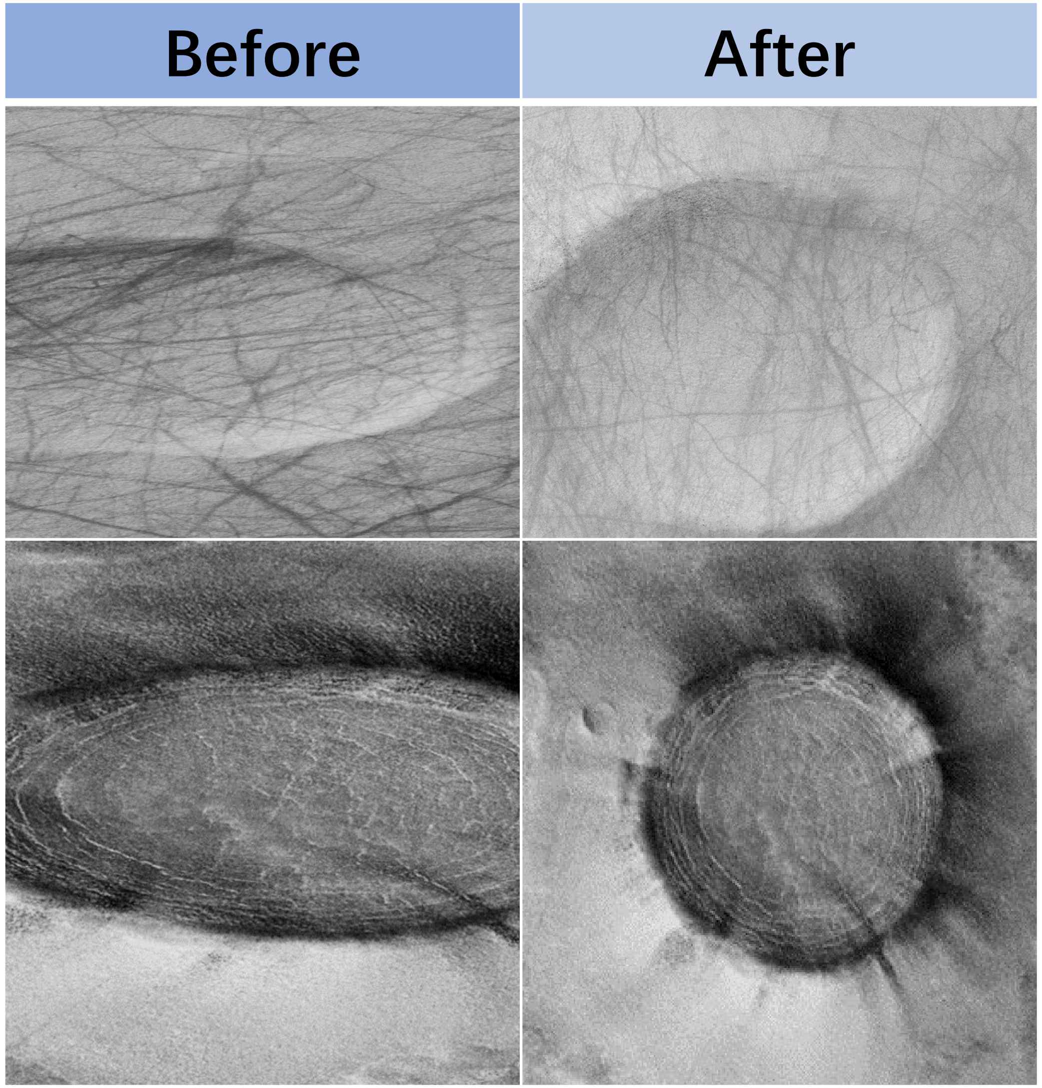


Equirectangular Ellipse in the case of Earth

Source: Dickson, J. L., et al. "The Global Context Camera (CTX) Mosaic of Mars: A product of information-preserving image data processing." Earth and space Science 11.7 (2024): e2024EA003555.

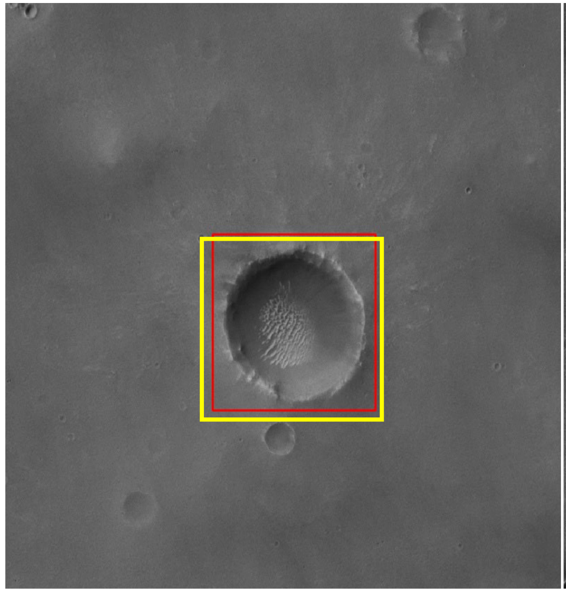
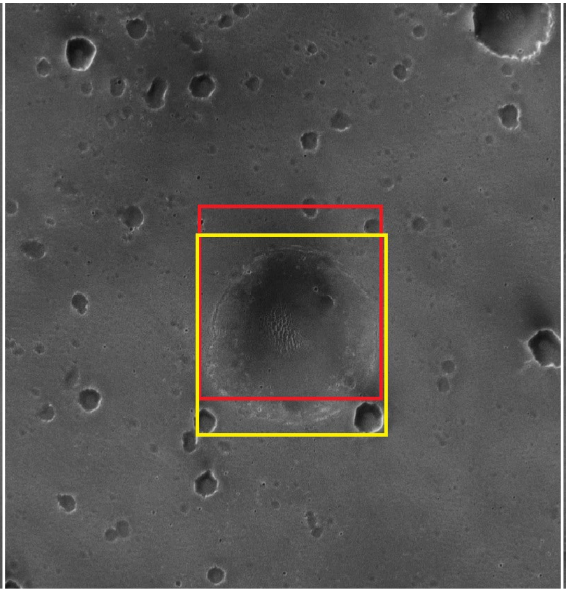
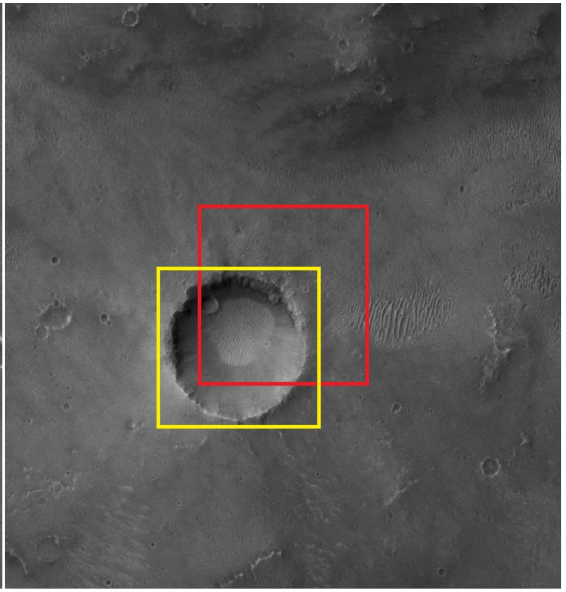
3. Workflow and Implementation

- **Note: to correct projection distortion**
- Projection: Equirectangular (equatorial radius 3,396,190 m, polar radius 3,376,200 m)
- Scale and Stretch: Bessel formula for solution of geodetic problem



3. Workflow and Implementation

- **Step3: Correction by ML methods**
- **Assumption: Centric original centroid**
- **Threshold Metric: Intersection over Union (IoU) & YOLOv5 confidence**

Correct Position (IoU>0.5 &confidence>0.5)	Validated Position (0.5>IoU>0.33 &confidence>0.5)	IoU≤0.33 (Fail to validate / no detection)
		

4. Discussion of Methodology

- **1. Efficiency**
- Hardware Dependency:

    Large Volume Device: Hard Disk Drive up to 12 terabytes
    Solid Disk Drive: minimum space of several gigabytes (to store instantaneous activated tiles)

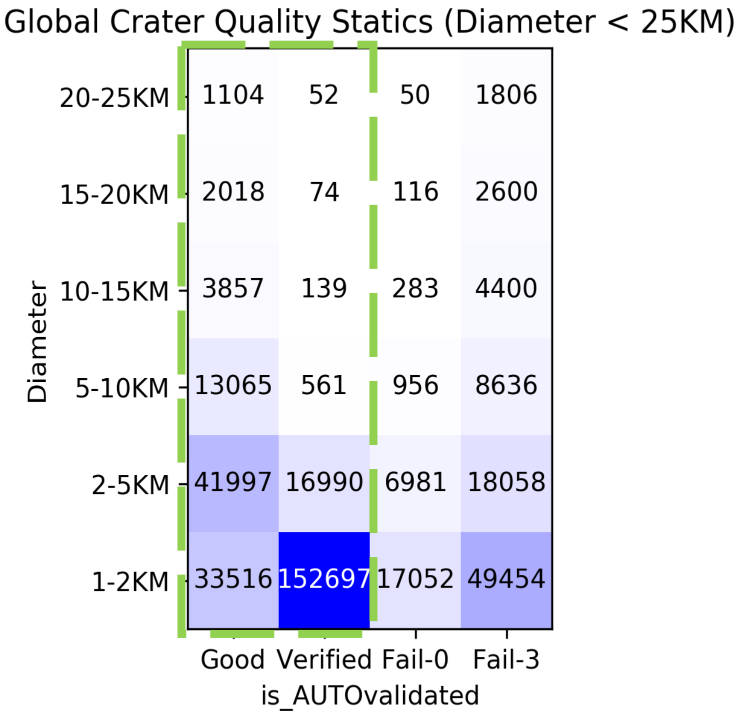
    CPU: intel i7-1067G7 (consumer product)

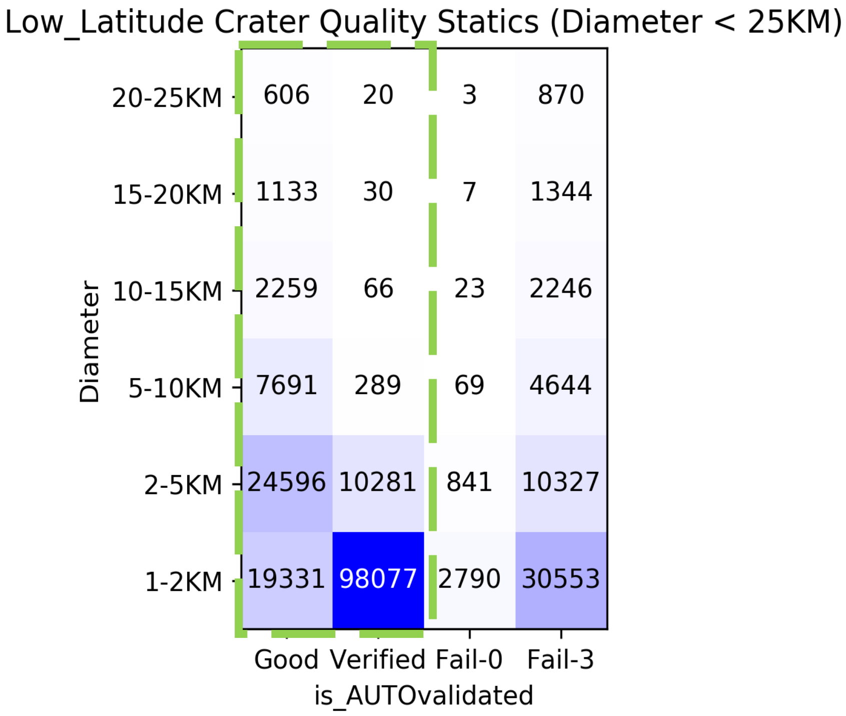
    GPU: NVIDIA MX350 (Memory 2GB, ran with YOLOv5 small)

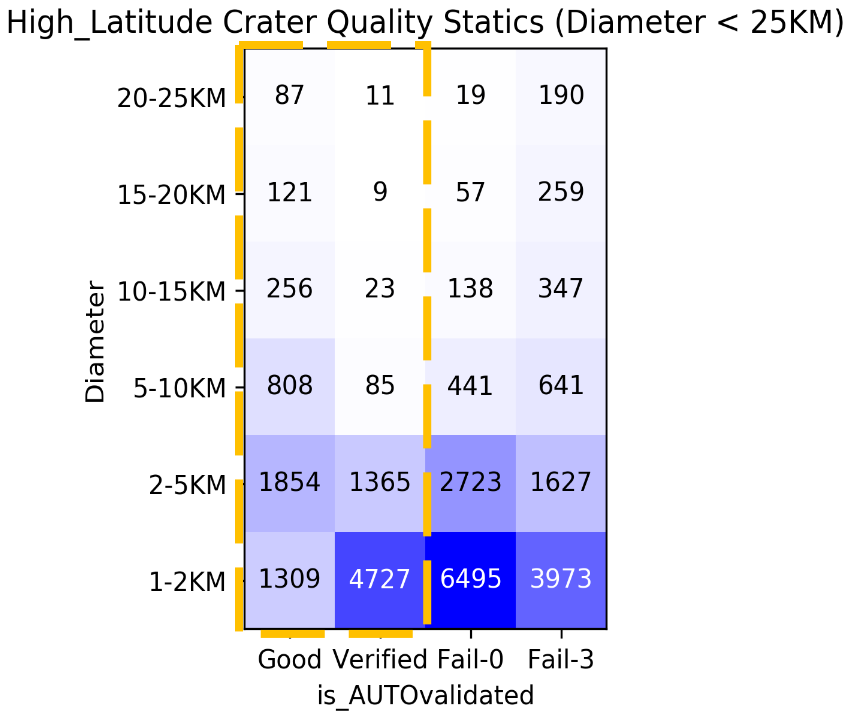
- Complete session up to 48~72 hours

4. Discussion of Methodology

- **2. Accuracy**

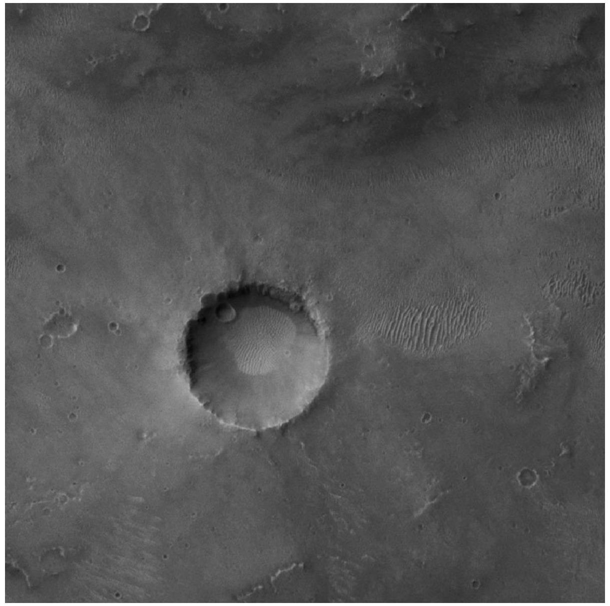




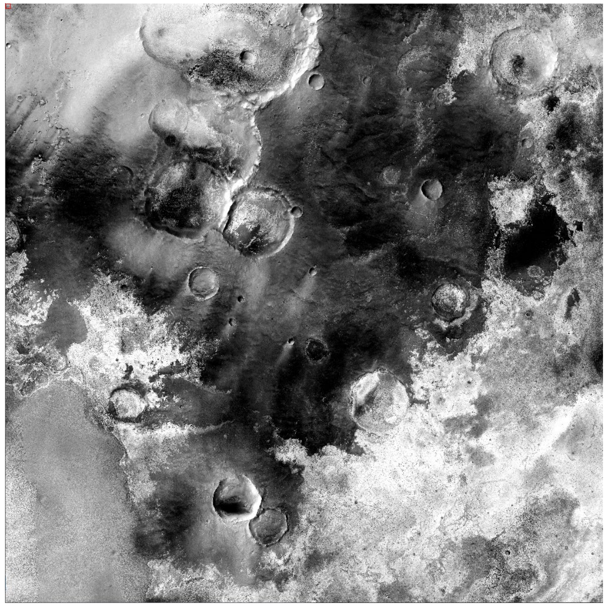


4. Discussion of Methodology

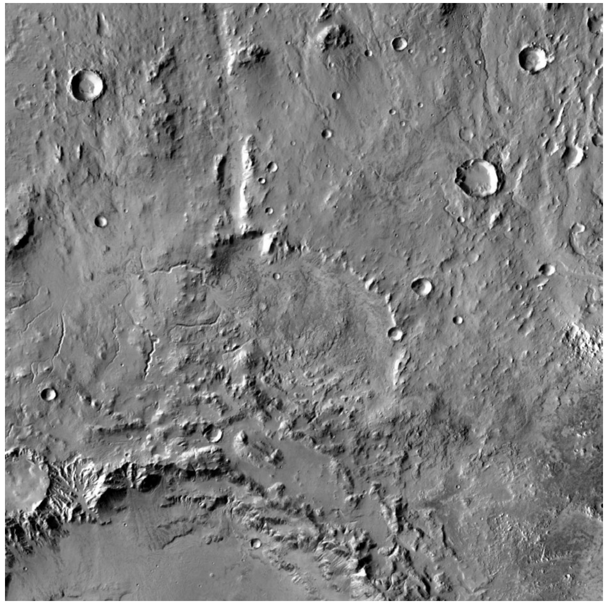
- **3. Suggestion for Underperformance**



Typical Crater
(elegant circular)



Very Large Crater
(up to 100 km)



Hard to name it a crater
(quasi-circular depression)

5. Conclusion

- We obtained crater images from Murray Lab's CTX mosaic tiles using location data from the Robbins crater dataset.
- We used geographic methods to trim, sew, and scale the images to their original shapes.
- The YOLOv5 module accurately corrected the locations of small craters at low latitudes but struggled with large craters, polar craters, and craters lacking visual structure.