SMART INDIA HACKATHON 2024

SMART INDIA HACKATHON 2024

TITLE PAGE

- **Problem Statement ID –** SIH1732
- **Problem Statement Title -** Enhancement of Permanently Shadowed Regions (PSR) of Lunar Craters Captured by OHRC of Chandrayaan-2
- **Theme -** Space Technology
- **PS Category -** Software
- **Team ID -** VITB-SIH2024-47
- **Team Name -** Team Arsenal

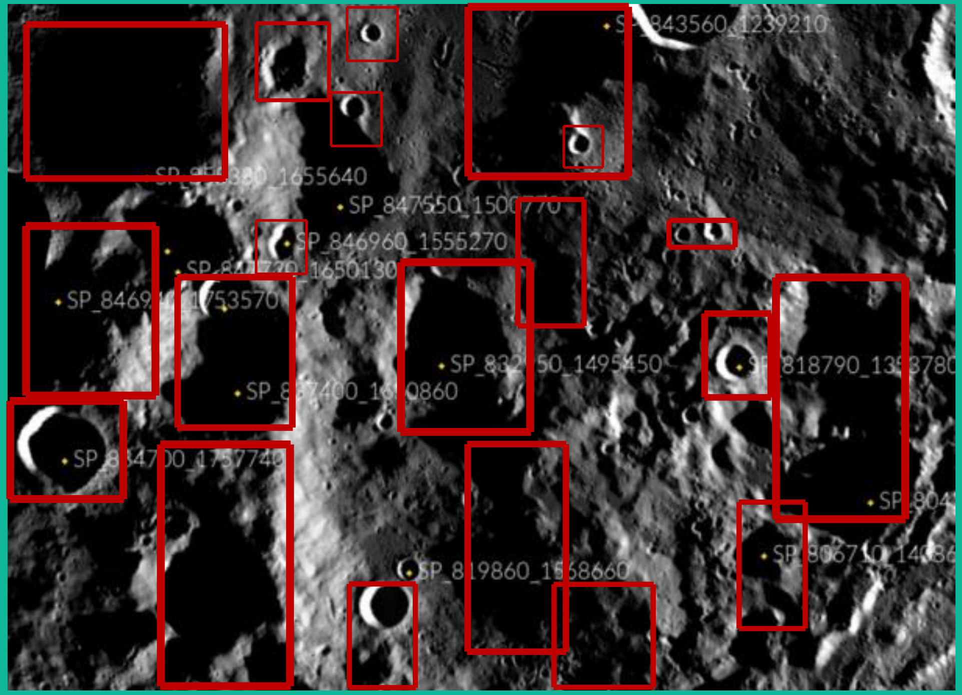
TEAM
ARSENAL

IDEA TITLE

SMART INDIA HACKATHON 2024

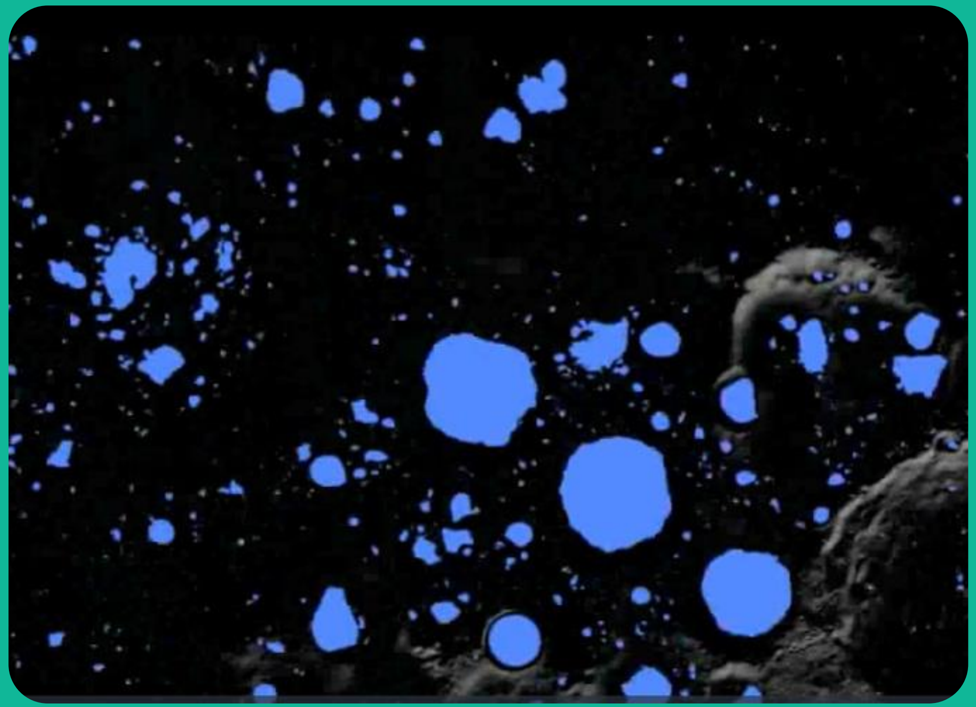
• Proposed Solution - TAMOHAR

TAMOHAR (Origin: Sanskrit, tamas darkness, and hara who removes) is a software that aims to open up the PSR data captured by the OHRC of Chandrayaan-2 to a world of new possibilities by analyzing and enhancing the low light images.



Proposed Idea

- Researches have shown the presence of water/ice in Permanently Shadowed Regions of the Moon.
  - The imagery made from the sensors can be used to detect craters, and map possible landing spots.
- For training the model, in order to generate dataset, existing sunlit images can be used as the expected output and artificially darkening some spots and adding noise can be used as input image.
- Tilling approach is used for better management of the memory when dealing with high resolution images.



Helpful for the nation

- The hidden water/ice deposits can have significant impact on our current knowledge of the moon.
- The data from PSR regions, mostly located at lunar poles, containing geomorphological data is scarce.

TEAM ARSENAL

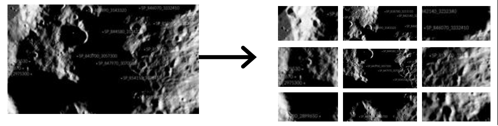
TECHNICAL APPROACH

SMART INDIA HACKATHON 2024

METHODOLOGY

1 DATA COLLECTION
Obtain raw **low light images** from the OHRC of Chandrayaan-2.

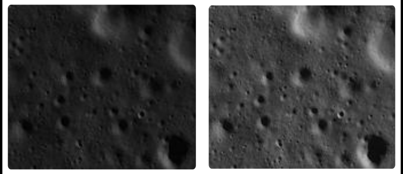
2 PRE-PROCESSING
The high resolution images will be tiled to smaller resolution.



3 MODEL SELECTION
Optimize for **PSNR ≥ 40** to ensure high-quality output.

4 CUSTOMISATION
Adapt the model to be **compatible with Chandrayaan-2's** onboard processing modules.

5 MODEL TRAINING
Implement techniques to **prevent noise amplification** during signal enhancement.



Input Paired Output
Retinex-Net and AutoEncoder

6 VALIDATION
Perform **cross-validation** to ensure robustness across different lunar terrains.

7 TESTING
Evaluate **model performance** in terms of processing speed and accuracy.

8 DEPLOYMENT
Deploy the model on **Chandrayaan-2's** data processing pipeline.

9 **Enhancing** low light images of **lunar poles**, captured by the OHRC on Chandrayaan-2.

10 POST-PROCESSING
Use enhanced images to produce high-resolution **Digital Elevation Models.**

11 ANALYSIS
Collaborate with scientists for interpreting the **geomorphological data.**

EXISITING WORKS

CIDNet
The paper introduces CIDNet, a low-light image enhancement method using a new Horizontal/Vertical-Intensity (HVI) color space and Lighten Cross-Attention (LCA) module to reduce artifacts and improve detail and noise suppression, outperforming existing techniques.

Global Diff
The paper presents a diffusion-based method for low-light image enhancement that uses curvature and uncertainty-guided regularization to improve detail preservation, noise reduction, and contrast which contribute towards outperforming current available techniques.

Photon Net
A U-Net CNN trained on modified image pairs of sunlit lunar regions which represented errors arising from sources such as data compression applied when transmitting images to Earth. PhotonNet learned to simulate these errors and subtracted them from the images.

TECH STACK

Model Development
Keras, TensorFlow, PyTorch, python, NumPy, OpenCV

Web/App Development
mongoDB, django, aws Lambda, React, Streamlit

TEAM ARSENAL

FEASIBILITY AND VIABILITY

SMART INDIA HACKATHON 2024

- **Parallel processing of the tiled images** from high resolution to a lower resolution can save the time taken for prediction.
- Training a **Retinex-Net model** with the **artificially darkened surfaces** derived from the sunlit surfaces can act as a paired dataset and result in accurate generation of low noise and detailed images.
- **A lightweight model** with significant accuracy will generate images faster. Tiling algorithm will be used to ensure the same, and join the images back after prediction to the original resolution.
- **Digital Elevation Model (DEM)** of high resolution can be generated with the combination of input and generated image.

Challenges and risks

- High resolution images use a huge amount of memory.
- Even though OHRC has a spatial resolution of 0.25m/pixel, the model can misidentify a crater <1m as noise.
- Accurately map the crater(s) and avoid only illuminating the image.

Strategies to overcome challenges

- Tiling algorithms to divide the image into smaller resolutions for prediction.
- Denoising algorithms like used along with the identified <1m craters in training to prevent its removal.
- Using physics based models to determine the possible locations of crater(s).

TEAM ARSENAL

IMPACT AND BENEFITS

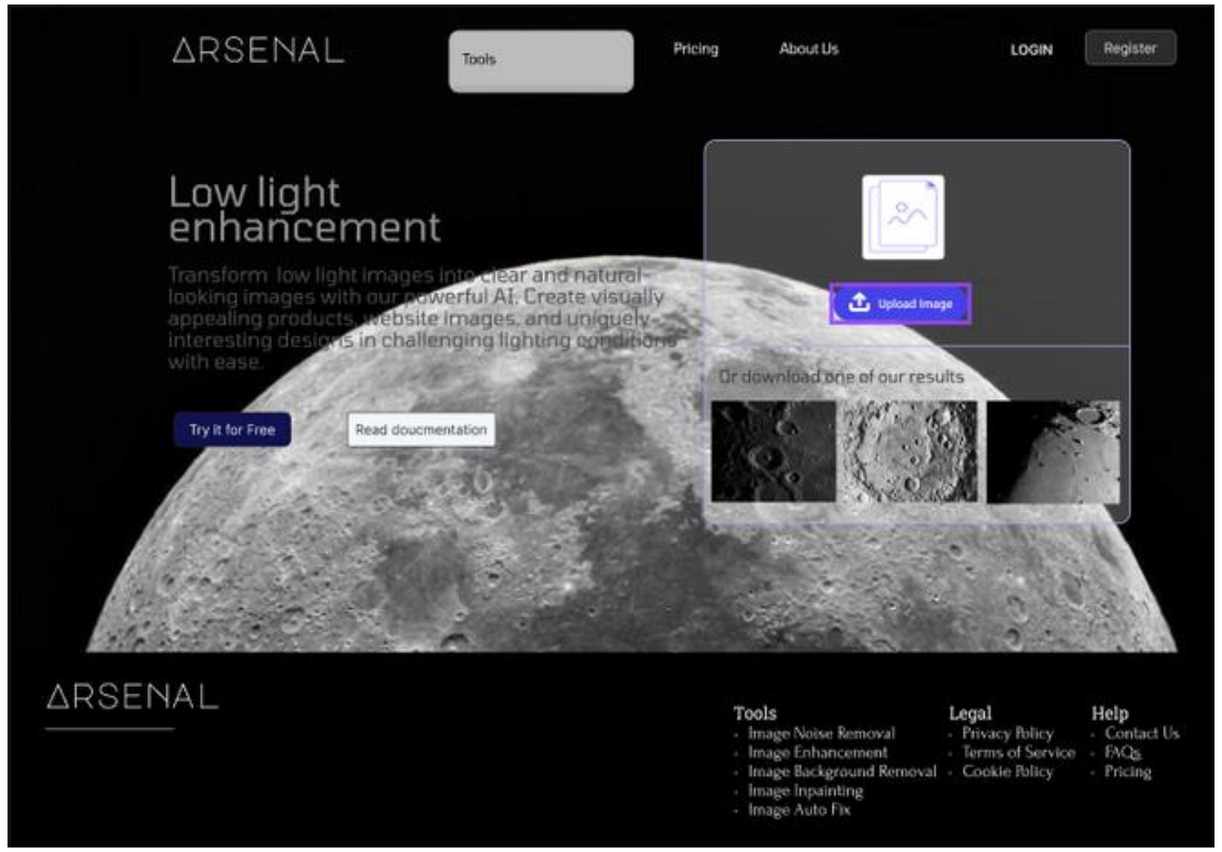
SMART INDIA HACKATHON 2024

Potential Impacts

- Drastically increases the chance to find an availability of resources like water, ice or minerals in these shadowed regions.
- Provides data for finding available safe-landing locations for future probing or exploration missions.
- Increases India's chances to find a perfect location to setup a lunar research base in near future

Potential Large scale Implementation

- A web-based service can be provided that can implement a similar model for usage



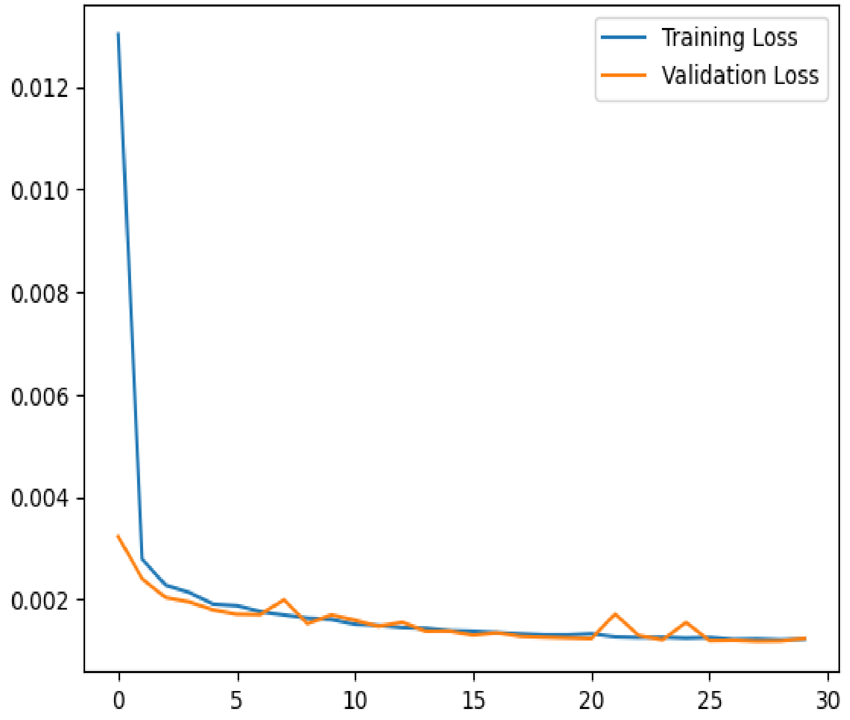
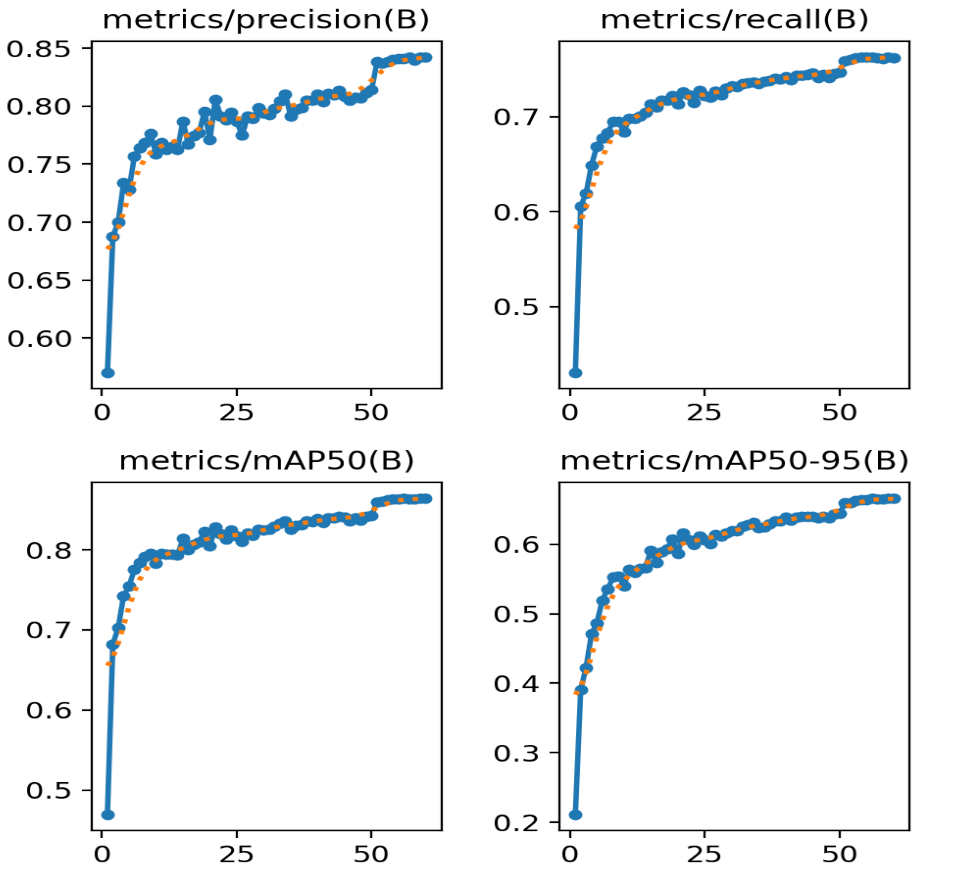


Image Denoising

Training Loss vs Validation Loss

Crater Object Detection



A Comparative Study

Here are the statistics based on the details of training of crater detection model.

TEAM ARSENAL

RESEARCH AND REFERENCES

SMART INDIA HACKATHON 2024

- "M4G2: A Low-Light Image Enhancement Benchmark Dataset and Evaluation" https://orbilu.uni.lu/bitstream/10993/45541/1/m4g2_neurips.pdf
- "The Moon's Permanently Shadowed Regions" - https://moon.nasa.gov/resources/97/the-moons-permanently-shadowed-regions/
- "LROC: Image of the Moon's Permanently Shadowed Regions" - https://www.lroc.asu.edu/images/979
- "Permanently Shadowed Regions of the Moon: A New Study Reveals Water Ice Accumulation" - https://www.nature.com/articles/s41467-021-25882-z
- "Extreme Low-Light Environment-Driven Image Denoising Over Permanently Shadowed Lunar Regions" - https://openaccess.thecvf.com/content/CVPR2021/papers/Moseley_Extreme_Low-Light_Environment-Driven_Image_Denoising_Over_Permanently_Shadowed_Lunar_Regions_CVPR_2021_paper.pdf
- "A Versatile Illumination System for Real-Time Terahertz Imaging" - https://www.researchgate.net/publication/343095168_A_Versatile_Illumination_System_For_Real-Time_Terahertz_Imaging
- "State-of-the-Art in Low-Light Image Enhancement on the LOL Dataset" - https://paperswithcode.com/sota/low-light-image-enhancement-on-lol
- "Deep Retinex Decomposition for Low-Light Enhancement"- https://arxiv.org/abs/1808.04560
- "Ultralytics YOLO Docs" https://docs.ultralytics.com/