

Team Hindsight

Design Review III



Introduction

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JPL's Mission to Understand Mars

JPL is a federally funded NASA research and development center whose primary role is to construct and operate planetary robotic spacecraft. Mars is a good place to start looking for answers for a few reasons. JPL has sent many missions to Mars with the goal of looking for evidence that Mars once had the conditions necessary to support life.

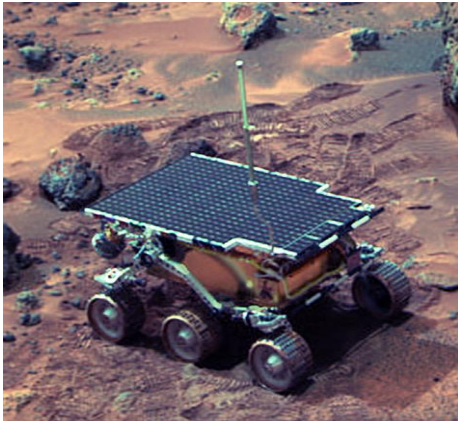


Figure 1.0. Pathfinder

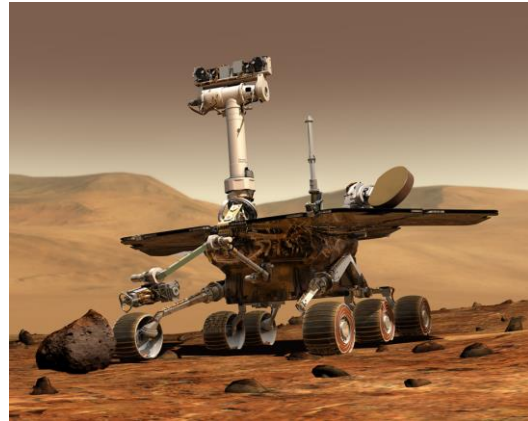


Figure 1.1. Spirit and Opportunity



Figure 1.2. Curiosity

Mars 2020 (M2020)

The primary goal of JPL's latest rover, M2020 will be to look for evidence of past life on Mars by analyzing and collecting samples of the Martian surface which will then be picked up, and returned to Earth by a future mission.

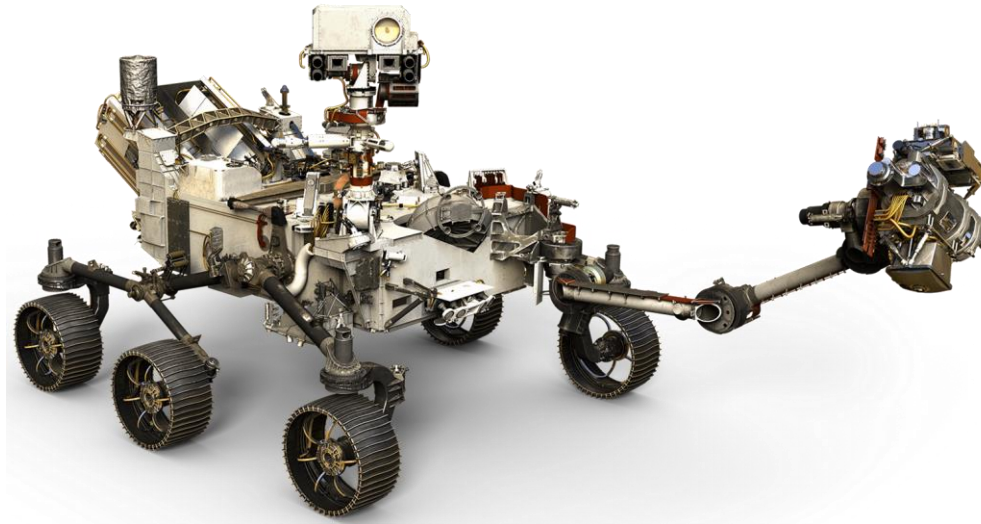


Figure 2.0. Mars 2020

Challenge facing JPL

When the rover drills it creates dust that obscures the hole. JPL's solution is to use compressed gas to blow dust out of the hole.



Figure 3.0. Before dust removal

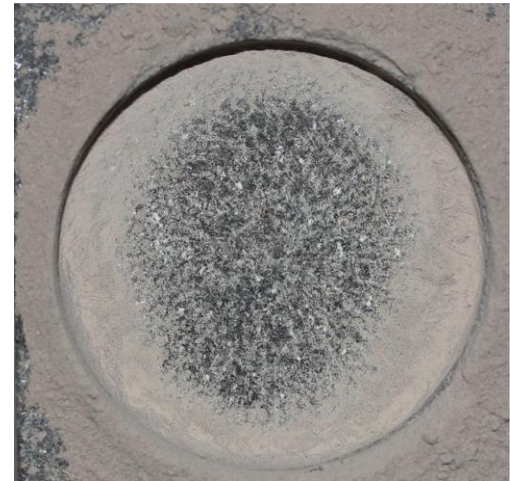


Figure 3.1. After dust removal

Why JPL's testing method is a problem:

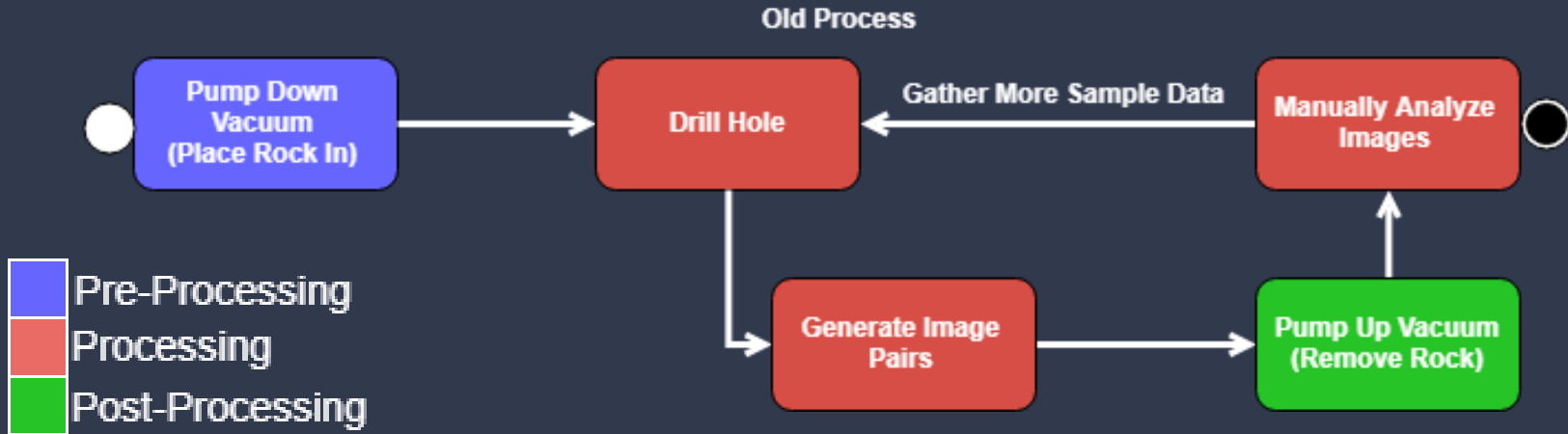


Figure 4.0. JPL Testing process

- Slow
- Inconsistent
- Could be better

Solution Overview

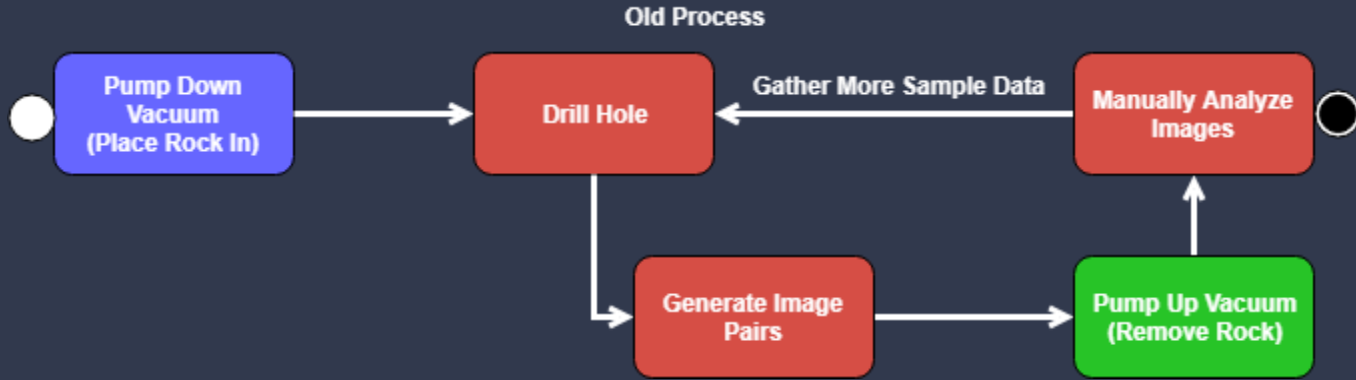


Figure 5.0. Old process from JPL

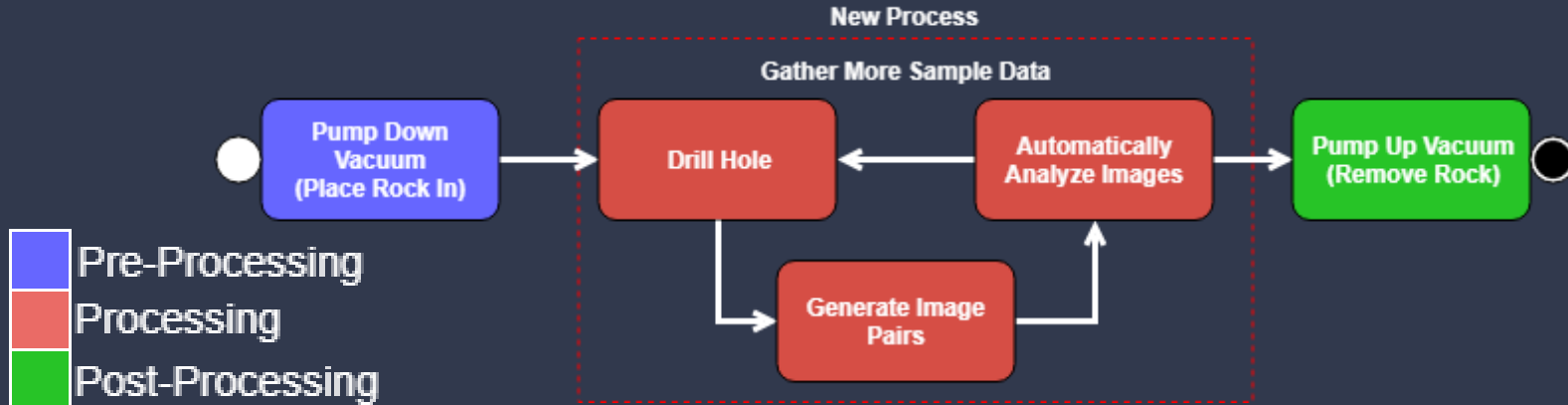


Figure 5.1. New process from our solution

Our Solution

Our software includes the following to the process:

- **Faster :**
 - No longer need to depressurize vacuum chamber
 - Image analysis speeds up to less than 5 minutes (from one hour)
- **More consistent:**
 - For all images per rock type
 - Less prone to human error
- **Further improvements and flexibility**
 - Can be parallelized
 - Algorithms added or changed

Requirements/Specs review

- Functional

- Handle batch of images
- Analyze image(s) for dust
- Allow user to adjust parameters
- Mark areas of dust coverage



Figure 6.0. Example abrasion analysis

- Non-Functional

- Display percentage of areas cleared
- Display after air blast and analyzed images in a GUI
- Should take no longer than a minute per image pair

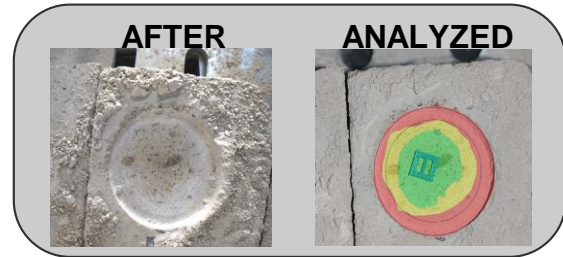
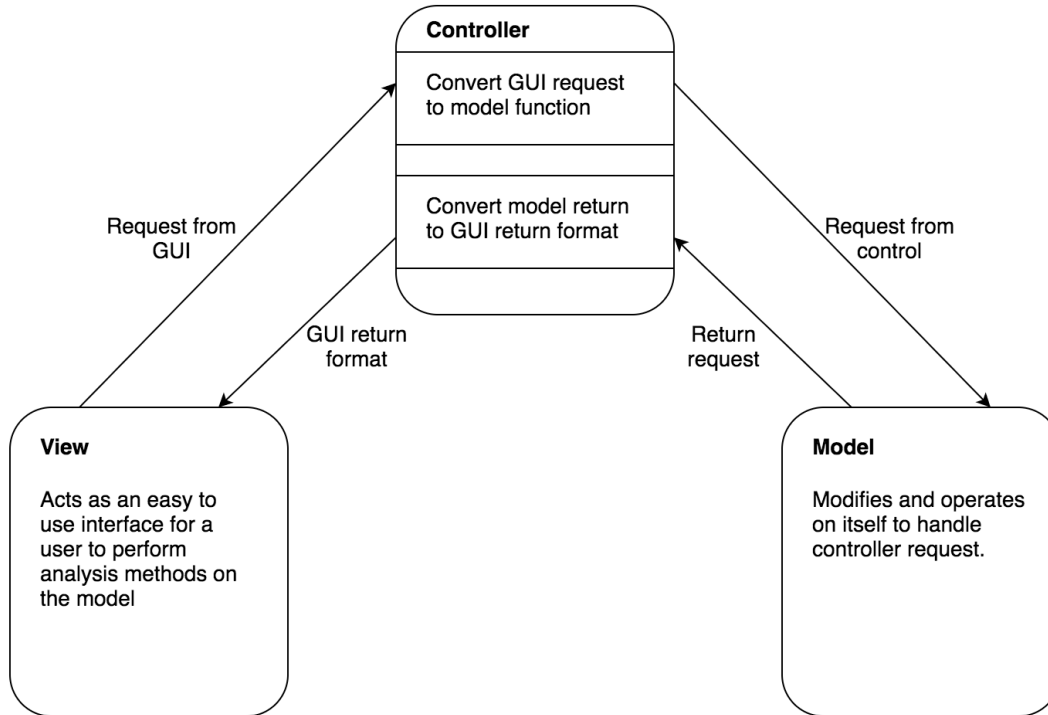


Figure 6.1. Examples of after and JPL analyzed image

Architecture Overview



- **Model View Controller (MVC)**
 - Graphical User Interface integration
 - Logic Separation
 - Parallel Development

Figure 7.0. High level architecture of the processing pipeline

Implementation

Model:

- Image
- Communicates with Controller through return values
- Uses third party libraries
 - Numpy
 - OpenCV



Figure 8.0. Before image data

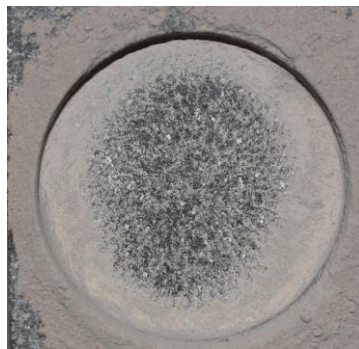


Figure 8.1. After image data

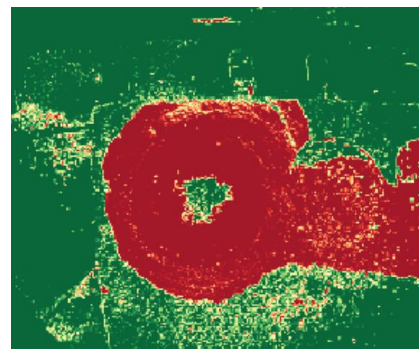


Figure 8.2. Analyzed image data

Implementation

View:

- Window Class
- Analysis Window Class
- Communicates with Controller using Config Class
- Uses tkinter

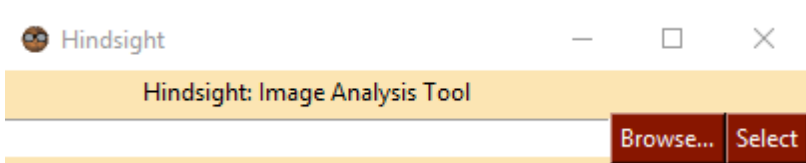


Figure 9.0. Window

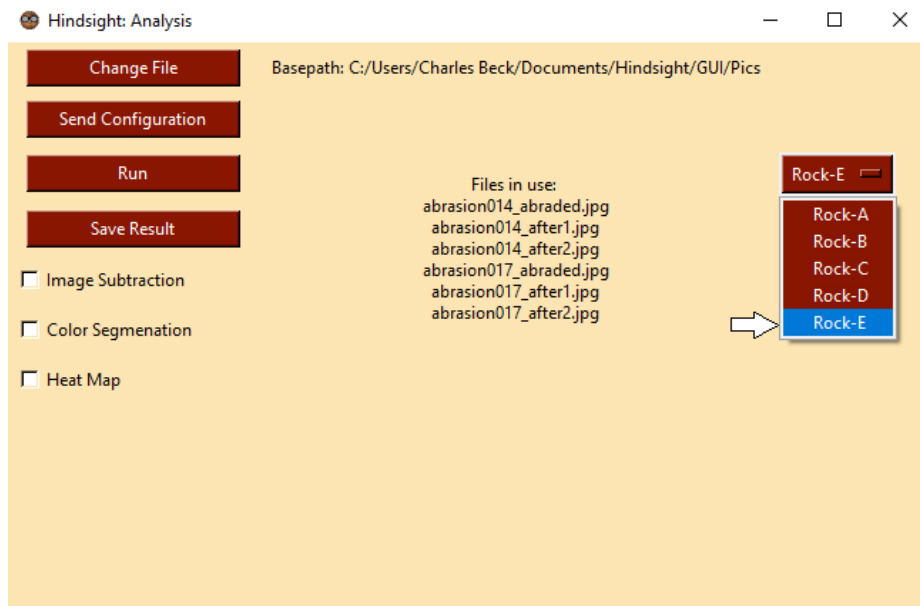


Figure 9.1. Analysis Window

Implementation

Controller:

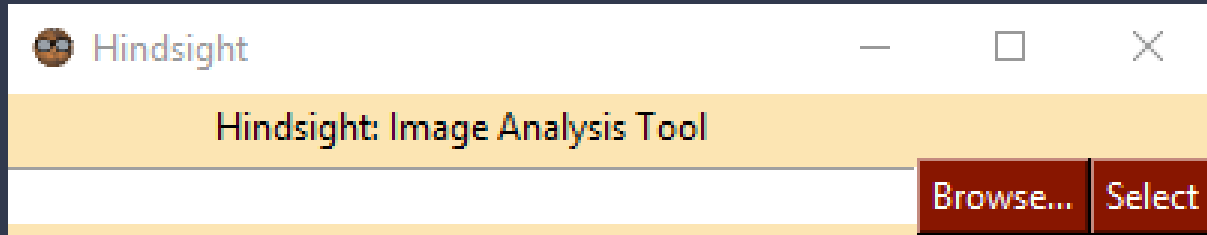
- Control Class
- control_funcs
- Sends returns from Model to View
- Applies Config functions to Model
- Uses Pandas Dataframe

	after_image	before_image	image_group	output_image
0	<image.image.Image object at 0x10601a6d8>	<image.image.Image object at 0x10601a128>	abrasion020_abraded.JPG	None

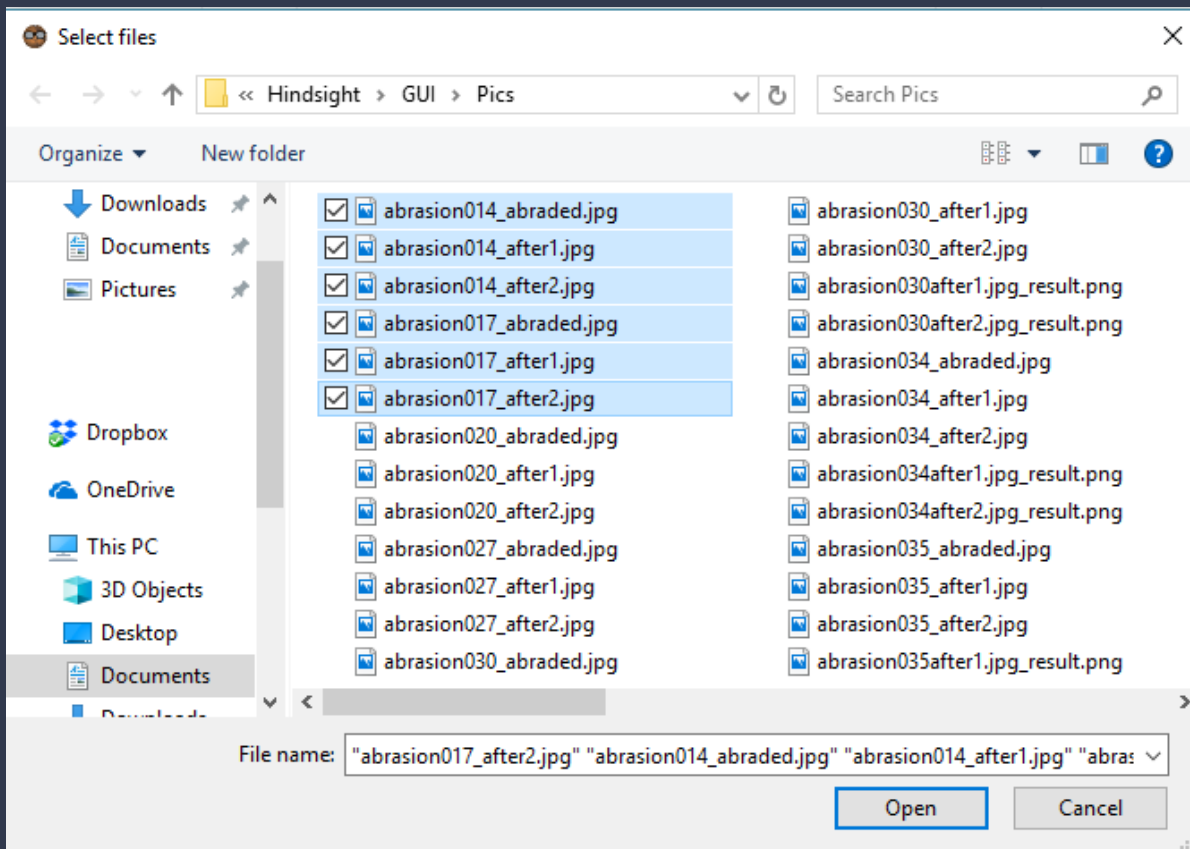
Figure 10.0. Controller Pandas Dataframe

Prototype Overview

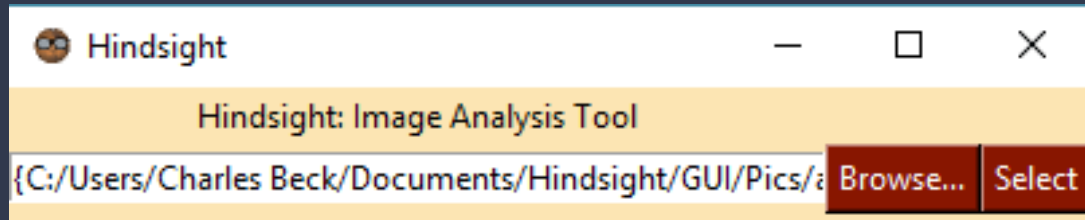
Start



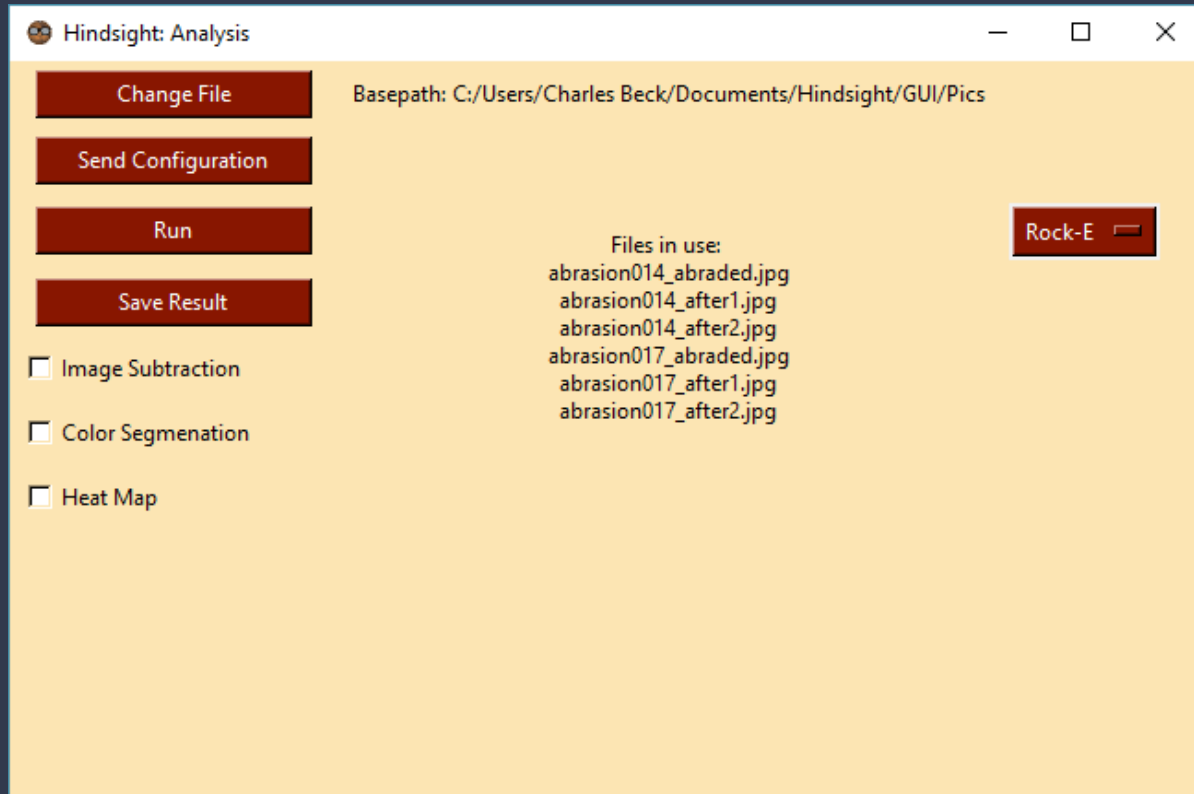
File Browser



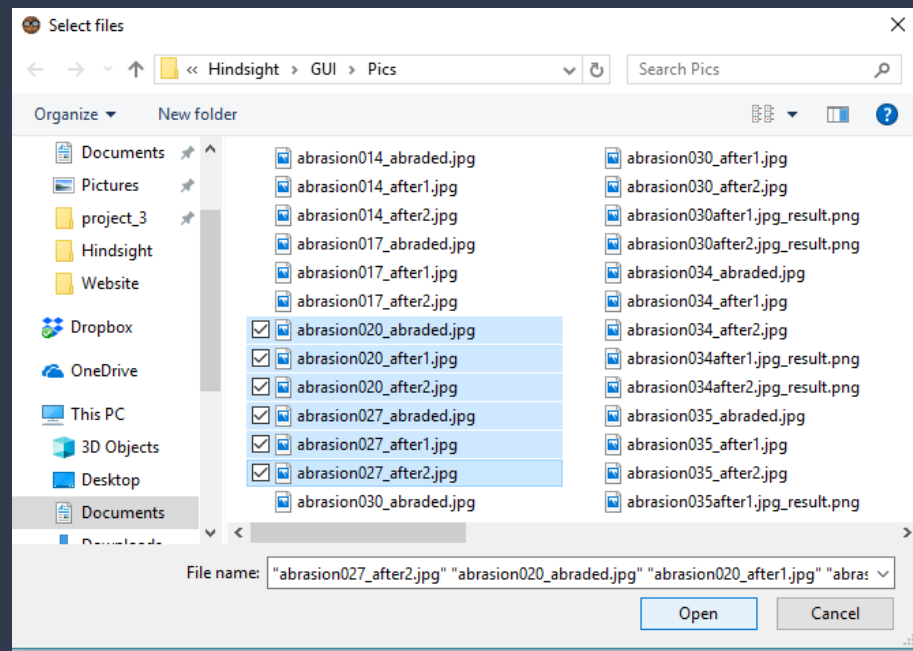
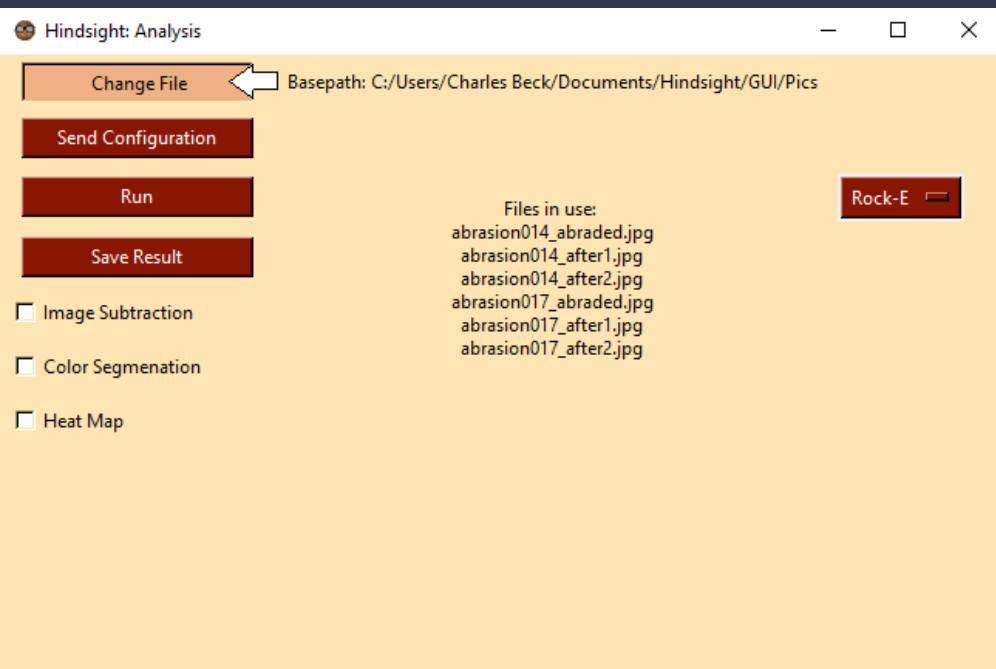
Selected



Analysis Window



Changing Files



Analysis Window – Rock Type

The screenshot shows the 'Hindsight: Analysis' application window. On the left side, there is a vertical toolbar with four buttons: 'Change File', 'Send Configuration', 'Run', and 'Save Result'. Below these buttons are three checkboxes: 'Image Subtraction', 'Color Segmentation', and 'Heat Map', all of which are currently unchecked. The main area of the window displays the 'Basepath: C:/Users/Charles Beck/Documents/Hindsight/GUI/Pics'. Underneath, a list of files in use is shown: 'abrasion014_abraded.jpg', 'abrasion014_after1.jpg', 'abrasion014_after2.jpg', 'abrasion017_abraded.jpg', 'abrasion017_after1.jpg', and 'abrasion017_after2.jpg'. On the right side, a dropdown menu is open, showing a list of rock types: 'Rock-A', 'Rock-B', 'Rock-C', 'Rock-D', and 'Rock-E'. The 'Rock-E' option is highlighted in blue, and a white arrow points to it from the left.

Hindsight: Analysis

Change File

Send Configuration

Run

Save Result

Image Subtraction

Color Segmentation

Heat Map

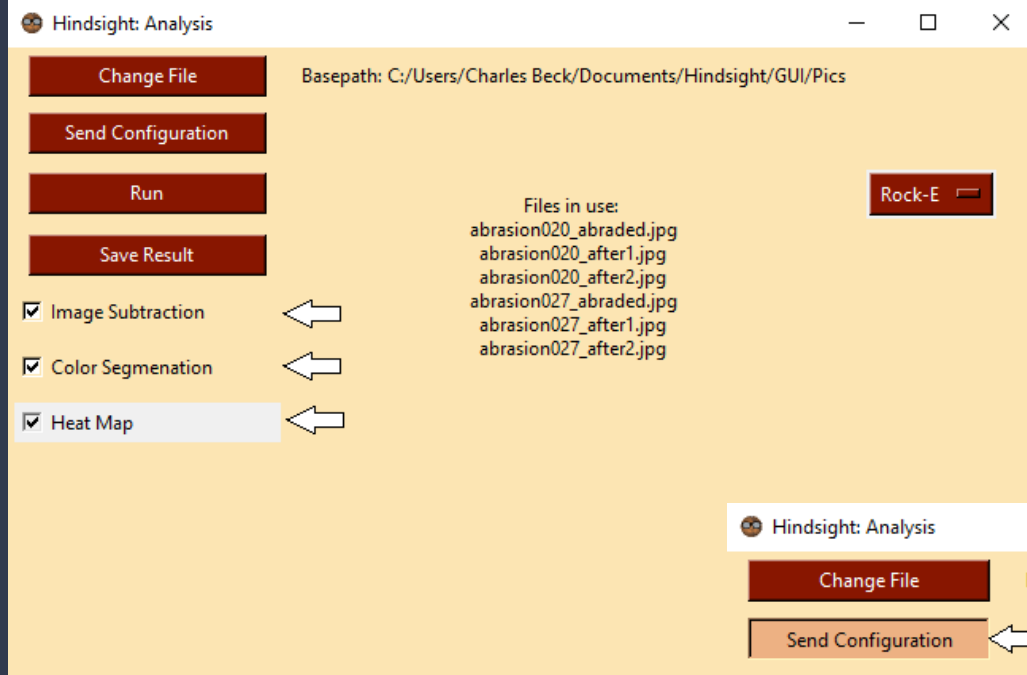
Basepath: C:/Users/Charles Beck/Documents/Hindsight/GUI/Pics

Files in use:

- abrasion014_abraded.jpg
- abrasion014_after1.jpg
- abrasion014_after2.jpg
- abrasion017_abraded.jpg
- abrasion017_after1.jpg
- abrasion017_after2.jpg

Rock-E

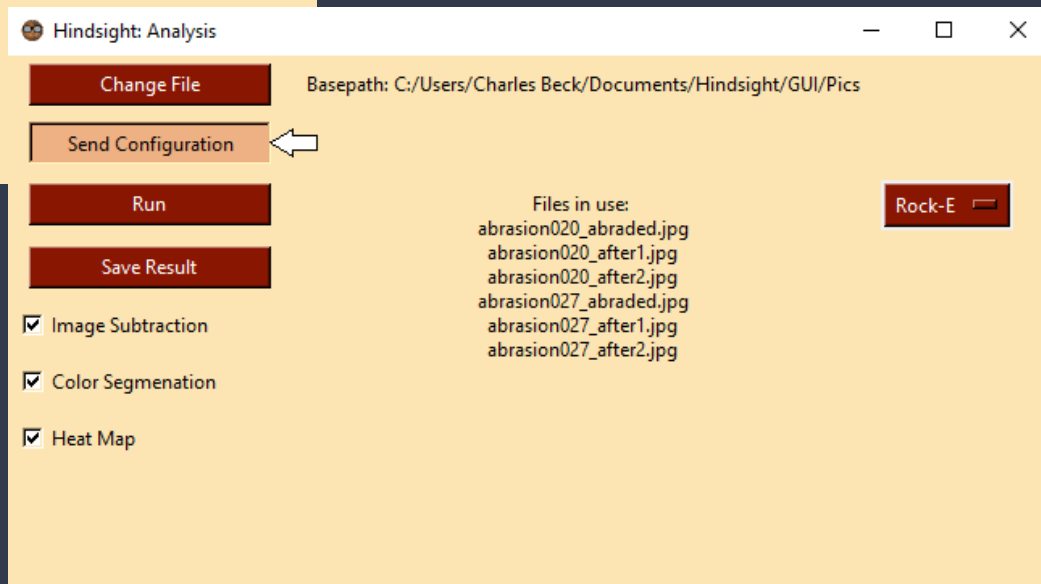
- Rock-A
- Rock-B
- Rock-C
- Rock-D
- Rock-E



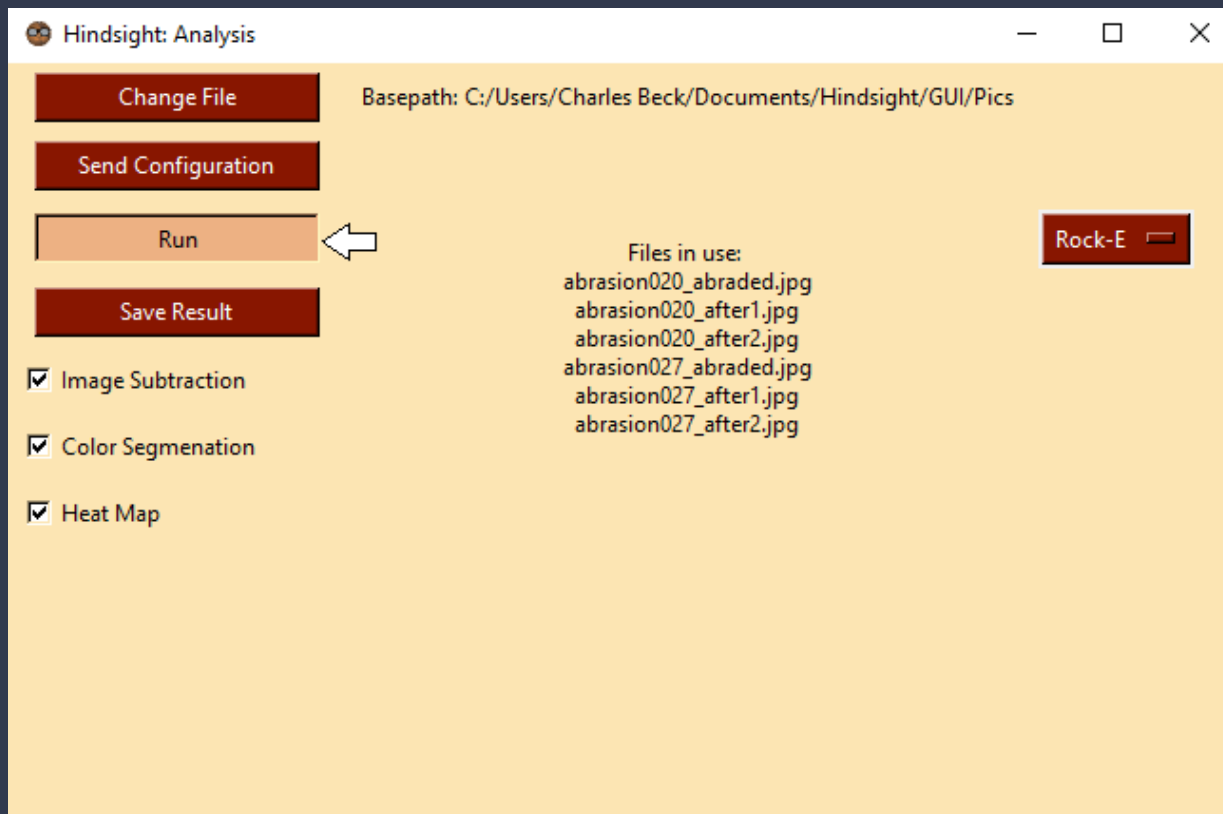
Check Image Analysis Options



Send Configuration to Control



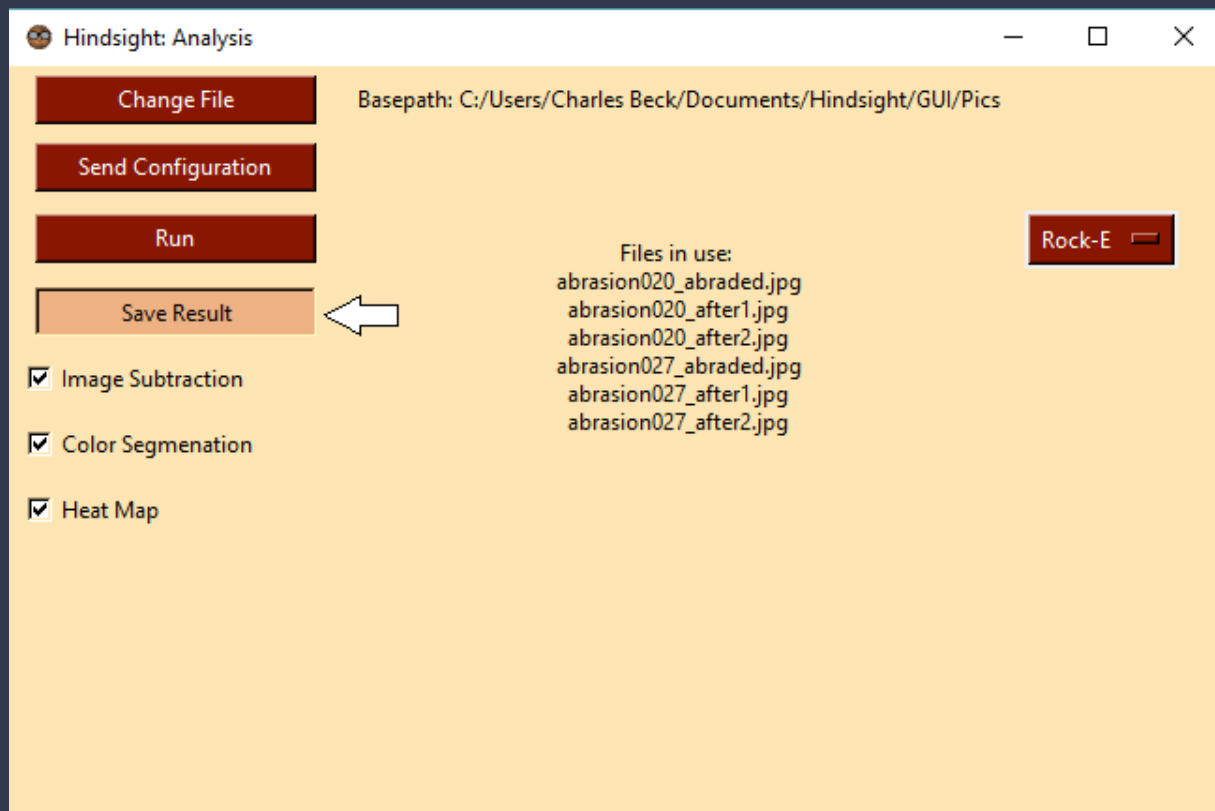
Running Analysis



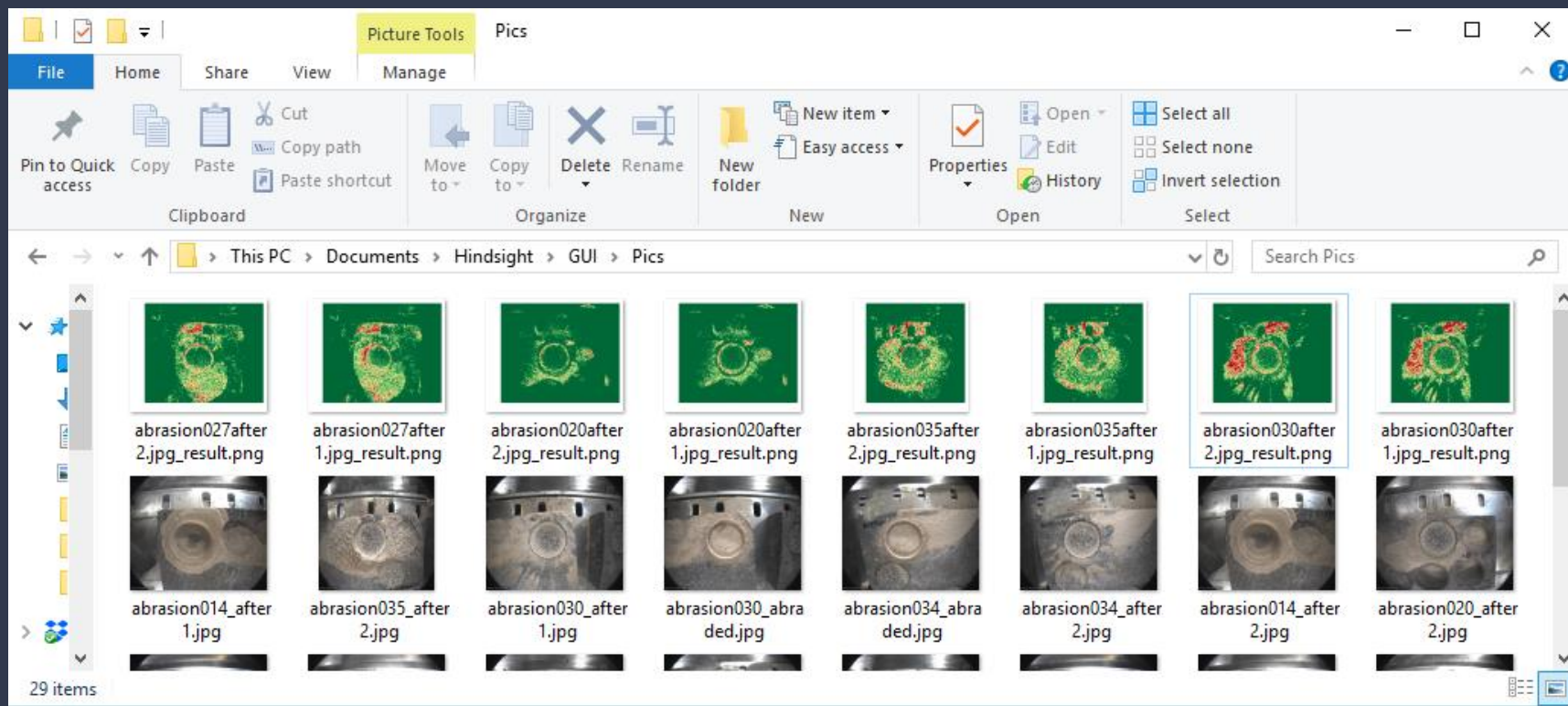
Output- Display For Each Analyzed Image



Save



View Saved Images



Challenges and Resolutions – From DR2

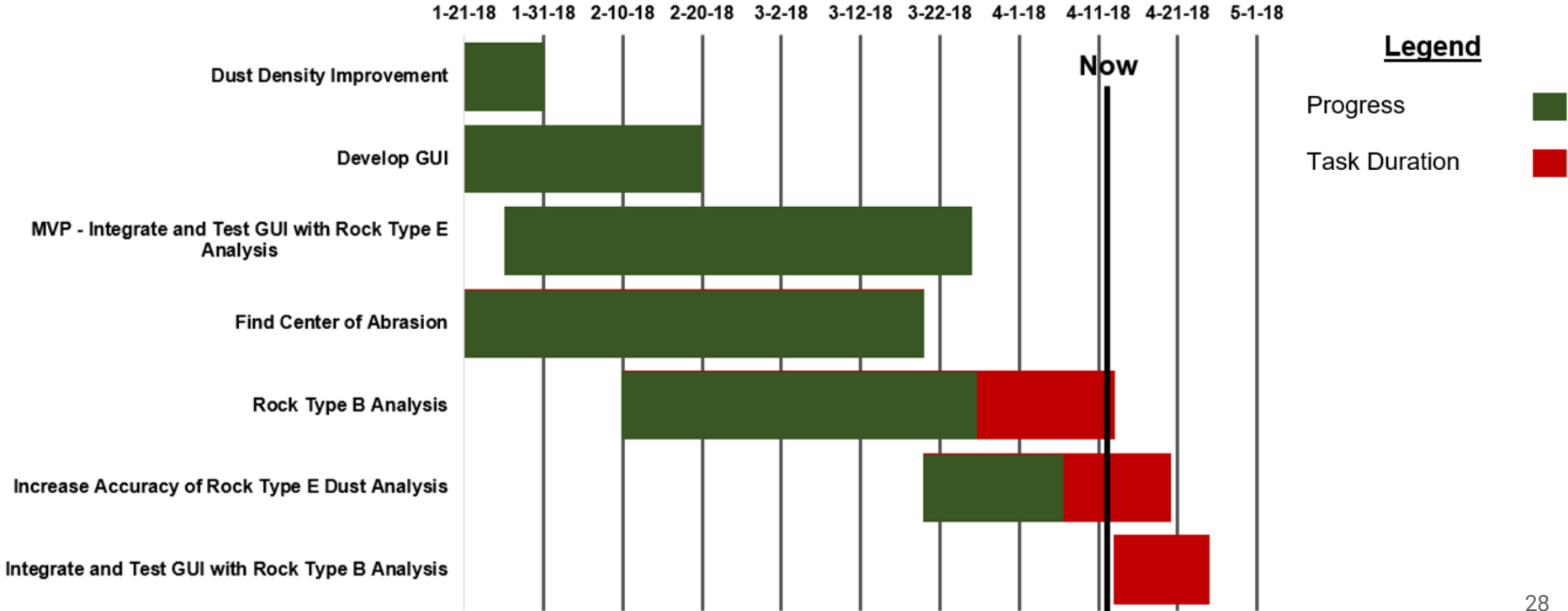
- Edge detection
 - After applying multiple algorithms and methods for detecting the edge, we found they led to a dead end
 - Resolution: Client suggested we do it based on camera parameters
 - Another team at JPL is working on edge detection alone
 - Status: Resolved
- Color segmentation for other rock types
 - What we currently have for Rock Type E doesn't work/may not work for other rock types
 - Resolution: Each rock type has a customized algorithm
 - Status: Have prototype for Rock Type B with further improvements on the way

Challenges and Resolutions – New

- Dark areas in abrasion image
 - Some abrasion images have shadows in the hole and this messes up the accuracy of our analysis tools
 - Resolution: Research techniques and test mask for detecting dark regions



Schedule



Testing Plan: What we are testing

- **Image Processing/Analysis**
 - Use of unit tests to enforce the correctness of our image processing, and analysis algorithms
 - Test image processing algorithms for producing a dust mask matching JPL's analysis
- **Module Communication**
 - Testing that all modules are integrated correctly using integration tests
 - Confirms that our system is able pipe data between modules with the desired result
- **GUI Testing**
 - Testing the GUI and get user feedback from our client on displaying final analysis
 - Develop a more robust and user friendly GUI

Testing Plan: How we'll respond to our testing

- Image Processing/Analysis
 - Iterative adjustment of Processing/Analysis algorithms to better match JPL's analysis
 - Will be a continuous process and adjusted as the need arises
- Module Communication
 - Errors in communication between modules will be handled as they arise
 - Adjustments will be made to ensure correct data is being communicated between modules
- GUI Testing
 - Will be sent to JPL for a period of testing and comeback closer to the end of the semester
 - All GUI modifications will be done in a week long period

Conclusion

- Client and Problem
- Solution Vision
 - Take in a batch of images
 - Automatically apply computer vision algorithms to detect dust
 - JPL can then run multiple tests in a single vacuum chamber pump down session
 - Get feedback on how effective their gas Dust Removal Tool is
- Overview of:
 - Requirements/Specs
 - Architecture
 - Implementation
 - Prototype
 - Challenges and Resolutions
 - Testing Plan
- What's Coming Up for Team Hindsight

Sources

<https://mars.nasa.gov/programmissions/missions/present/2003/>

https://en.wikipedia.org/wiki/Mars_Pathfinder

<https://www.jpl.nasa.gov>

<https://mars.nasa.gov/mars2020/mission/rover/>