Team Hindsight

Design Review I

Introduction

Hunter Rainen - Team Lead, Documents/Research
Alexanderia Nelson - Release Manager, Documents/Research
Adam Paquette - Architect , Coder
Charles Beck - Recorder, Coder

Client: Iona Brockie NASA\JPL - Caltech

Faculty: Dr. Doerry

Mentor: Austin Sanders

Problem Statement - Mars 2020 (M2020) Mission

- The main objective of the Mars missions, are to find evidence of past life on the Martian surface.
- This mission, M2020, takes the next step by not only seeking signs of habitable conditions on Mars in the ancient past, but also searching for signs of past microbial life itself. - JPL
- JPL's latest Mars rover will have a suite of tools for discovering a variety of scientific information. One tool that directly affects Team Hindsight's project is a drill. The rover will drill holes into rocks on Mars so that other instruments like PIXL and SHERLOC can further analyze with finer detail the composition of the Martian surface.

PIXL: Planetary Instrument for X-ray Lithochemistry

SHERLOC: Scanning Habitable Environments with Raman & Luminescence for Organics & Chemicals

Problem Statement Cont. - Mars 2020 Mission

- However, the process of drilling into rocks creates dust in and around the hole.
- This dust obscures the mineral and chemical makeup of rocks which the scientific instruments on board the rover are trying to analyze
- JPL’s current solution is to blow a puff of air into the hole (via compressed gas) to blow out any dust.
- Iona needs to know how effective this gas dust removal tool is at getting the dust out of any particular hole the rover might drill.

Problem Statement - What's Wrong

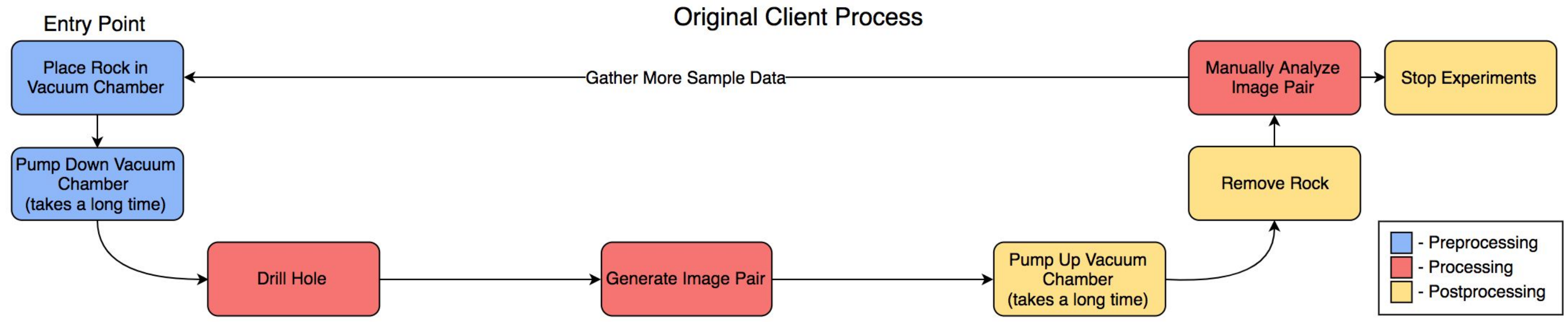


Fig 1. Diagram of JPL's original process for gathering data

- Testing Dust Removal System
  - Current Process
    - Slow process to simulate Martian atmosphere (requires vacuum chamber)
    - Lots of Data to analyze (JPL takes measurements from many sensors for each test)
    - Inaccurate (Human error)
    - Conflicting results (Two different humans may come up with different answers)
    - Tests can be invalidated (removing the test slab from vacuum chamber may disturb dust)

Solution Overview

- Image Processing Pipeline
  - Takes in a pair or pairs of images (before and after images of an abrasion)
  - Apply user/programmer defined algorithms to all pairs of images automatically
    - Same algorithms result in a consistent analysis
  - Output regionally defined image and associated data
    - Output Image
      - Clearly defines dust coverage
    - Associated Data
      - Hard percentages for each region

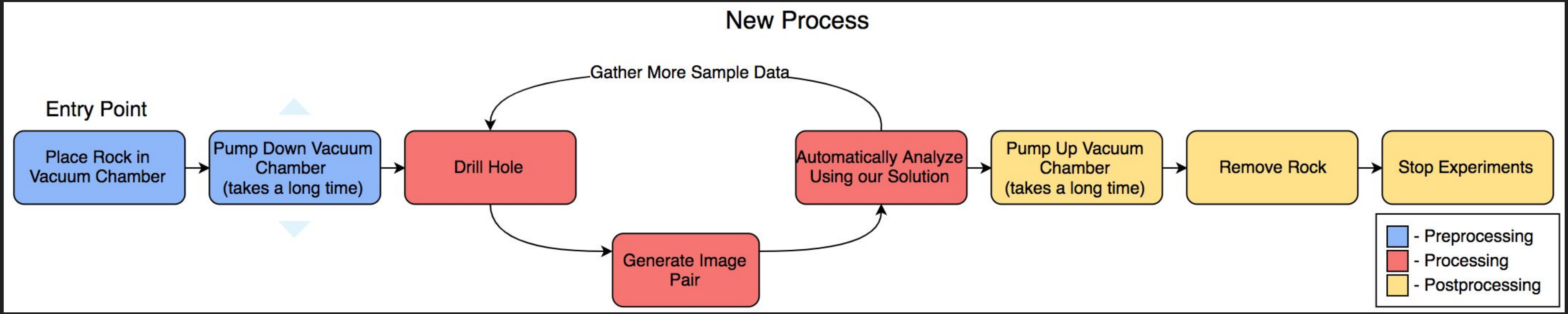


Fig 2. Diagram of the new process with our solution

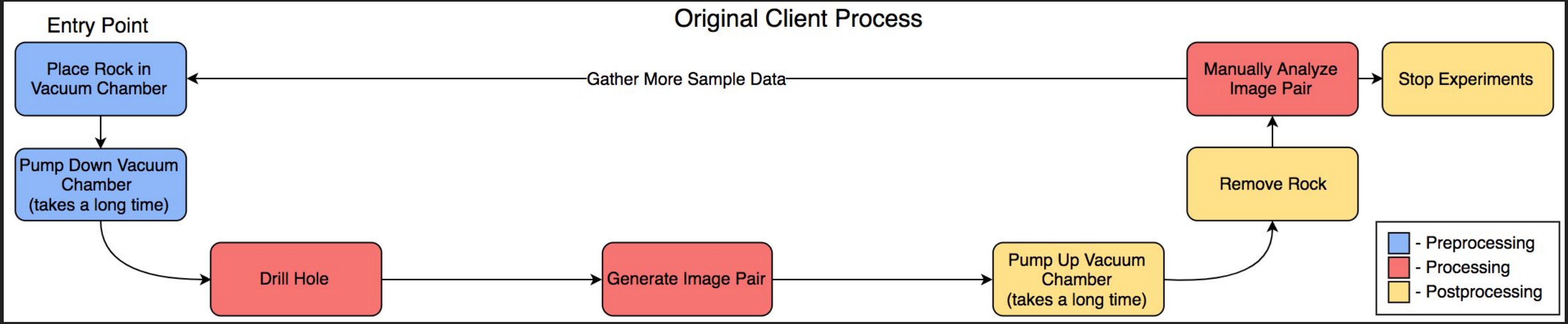


Fig 3. Diagram of JPL's original process for gathering data

Key Requirements - Functional

- Handle Batches of images
  - Select folder of images and run through program
- Analyze image(s) for dust
- Mark areas of dust coverage
  - Green
  - Yellow
  - Red
- Allow user to adjust parameters.

Figure 4 took 30-40 minutes to hand make

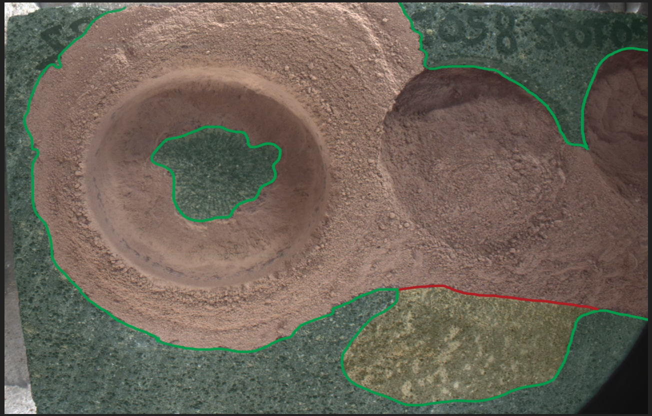


Fig 4. Example abrasion analysis

Key Requirements - Non-Functional

- Display percentage of areas cleared
  - Green = 70%-100% area of abrasion free of dust
  - Yellow = 40%-69% area of abrasion free of dust
  - Red = 0%-39%
- Display before air blast, after air blast, and analyzed images in a GUI

Fig 5. Examples of a before, after, and JPL analyzed image

- Should take no longer than a minute per image pair

Risks

Potential risks we foresee running into:

- Inaccurate algorithms
    - dust can be similar in color to rocks (hard to distinguish between the two)

  Likelihood: Possible to occur, Moderate

- Slow Run Time
    - Algorithms looking at large images (~ 2448 pixels × 2048 pixels)
    - Moderately sized image sets (2 - 10 images)

  Likelihood: Not very likely

Risks Continued

Potential risks we foresee running into:

- Comparing the wrong set of images
  - Variations of naming conventions.

  Likelihood: Not very likely

- Costing JPL testing time
  - May lose more time using their original method of testing.
  - Even if we ship an incorrect product, JPL has planned this mission without the involvement of our software and will complete their testing in their designated time.

  Likelihood: Not very likely

Mitigation

- Mitigate inaccurate algorithms
  - **First:** Take multiple (50px x 50px) samples
  - **Second:** Comparisons of what our programs sees as dust and what we have sampled as dust to validate results
  - **Third:** Stochastic Modeling
- Mitigate slow runtimes:
  - **First:** Subdividing large images
  - **Second:** Use less changes to images
  - **Third:** Integrate Parallelism
    - To shorten our program’s runtime, we will likely port to a faster language (eg. C++).

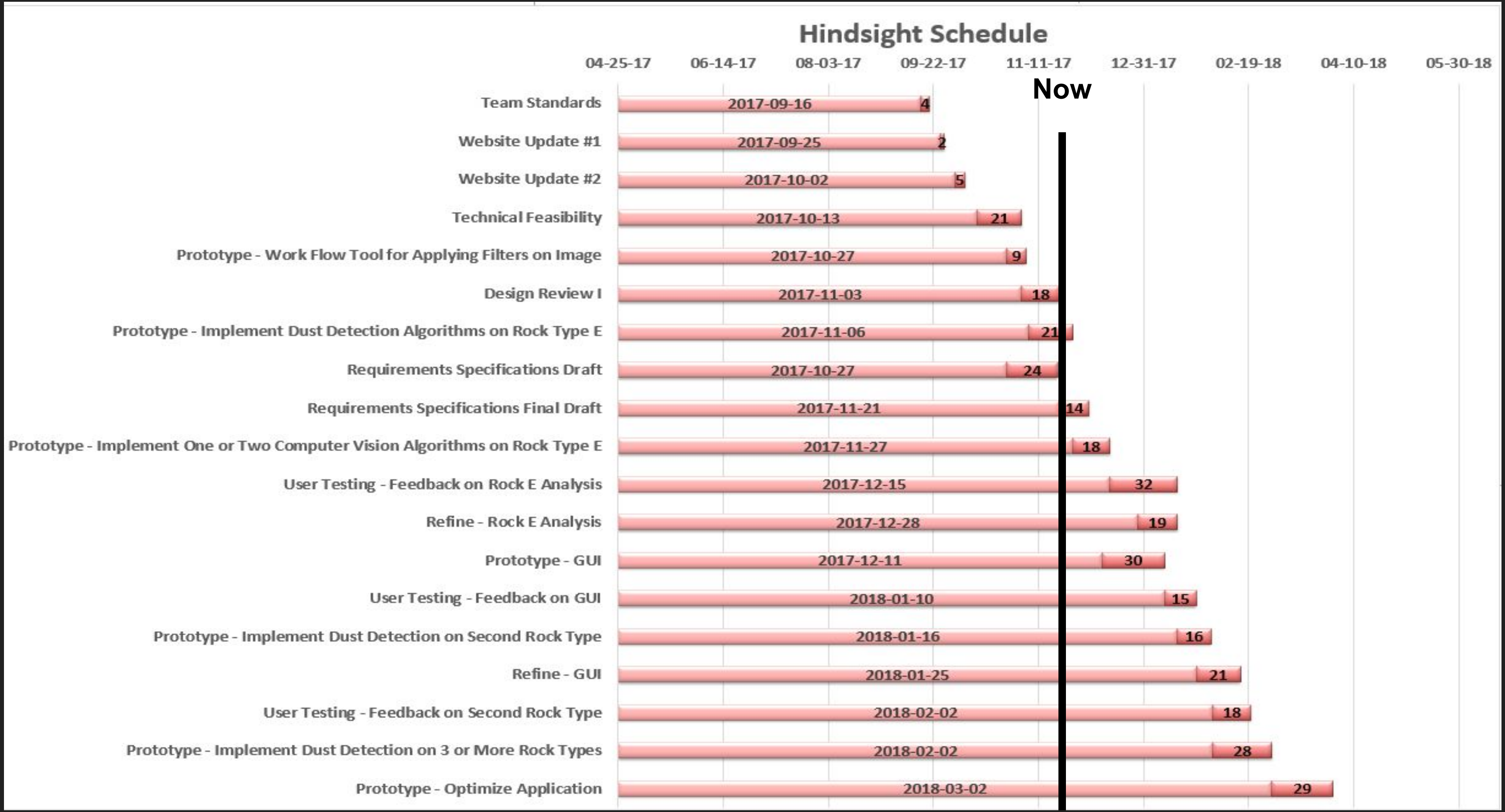
Mitigation Continued

- Mitigate comparing the wrong images:
  - **First:** Have a confirmed naming convention agreed upon by JPL and our team

- Mitigate costing JPL test time:
  - **First:** Compare their original results of JPL's analyzing to our programs results and confirm correctness.
  - **Second:** Refine results with better modeling techniques
  - **Third:** Vast testing, refinement, user testing

Section 3.1.3 and 3.2.3 in our Technical Feasibility document explains more options in greater detail.

Schedule



Hindsight Schedule
04-25-17
06-14-17
08-03-17
09-22-17
11-11-17
12-31-17
02-19-18
04-10-18
05-30-18
Now
Team Standards 2017-09-16 4
Website Update #1 2017-09-25 2
Website Update #2 2017-10-02 5
Technical Feasibility 2017-10-13 21
Prototype - Work Flow Tool for Applying Filters on Image 2017-10-27 9
Design Review I 2017-11-03 18
Prototype - Implement Dust Detection Algorithms on Rock Type E 2017-11-06 21
Requirements Specifications Draft 2017-10-27 24
Requirements Specifications Final Draft 2017-11-21 14
Prototype - Implement One or Two Computer Vision Algorithms on Rock Type E 2017-11-27 18
User Testing - Feedback on Rock E Analysis 2017-12-15 32
Refine - Rock E Analysis 2017-12-28 19
Prototype - GUI 2017-12-11 30
User Testing - Feedback on GUI 2018-01-10 15
Prototype - Implement Dust Detection on Second Rock Type 2018-01-16 16
Refine - GUI 2018-01-25 21
User Testing - Feedback on Second Rock Type 2018-02-02 18
Prototype - Implement Dust Detection on 3 or More Rock Types 2018-02-02 28
Prototype - Optimize Application 2018-03-02 29

Conclusion

- Client and Problem
- Our Solution Vision
  - Take in 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
    - And get feedback on how effective their gas Dust Removal Tool is
- Key Topics
  - Requirements Acquisition
  - Functional and Non-functional Requirements
  - Risks and Feasibility
- What’s Coming Up for Team Hindsight

Questions?

Sources:

https://mars.nasa.gov/mars2020/mission/overview/