CS486C – Senior Capstone Design in Computer Science

Project Description

Project Title: Image Analysis of Abraded Rocks to Determine Dust-Free Area	
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Project Overview:

The Mars 2020 rover is a NASA mission currently in development. This rover will investigate a region of Mars where the ancient environment may have been favorable for microbial life, probing the Martian rocks for evidence of past life. Throughout its investigation, it will collect samples of soil and rock, and cache them on the surface for potential return to Earth by a future mission.

The rover includes a drill and suite of drill bits. One type of bit is used to abrade the surface and create flat, smooth, dust-free patches below the weathered outer layer of rock. The science instruments on the turret of the rover will analyze the chemical, mineral, physical, and organic characteristics of these abrasions to determine where to collect samples. It is critical that the dust be removed from the abrasion, otherwise the rock below is obscured and the instruments will not get useful data.

The dust removal system is currently undergoing extensive development testing. To draw meaningful conclusions from the test data, it is necessary to determine what area of the rock is dust free. Currently, this is done by performing the test on a rock in a vacuum chamber, removing the rock from the chamber, placing a visual scale next to the abrasion, taking a photo, manually tracing the cleared area and the scale, then using the known dimensions of the scale to convert the measured area from pixels to millimeters. This causes a few problems.

- The measurements are subjective, they depend on who is tracing the dust-free area.
- The rock must be removed from the vacuum chamber between tests, so that the photo with the scale can be taken. This significantly slows down testing.
- Moving the rock from the vacuum chamber to the photo area has the risk of disrupting the dust state, invalidating that test.

The goal of this project is to create a small, user-friendly application to vastly improve this process, by automating the loading, dust analysis, and area measurement of rock sample images presented to the system. The output of the software product is essentially the same as for the manual process: a modified image annotated to outline the dust-free region, as well as meta-data about that image, notably including the dimensions/area of the dust-free region in units of the user's choice. Specific functionalities of the software will include:

Core Functionalities: A minimum usable product

- Application for processing given rock sample images for dust-free areas. The exact nature of the application (desktop standalone, server-based, etc.) will be determined in consultation between team and client in the early phases.
- Must accept either individual image files, or whole folders of images to allow instant single image or bulk processing.
- Must distinguish between dust-covered and dust-free rock; and extract appropriate measurements of the dust-free area based on camera and set-up calibrations automatically, without access to separate visual scale.
- Must handle at least one major rock type well (to prove the concept)
- Must display a visual of the area deemed dust-free, allow for the user to manually adjust, and re-calculate measurements afterwards.

Augmented Goals: A truly useful tool

- Improves dust-free algorithm based on user adjustment.
- Handles all five major rock types, including white rocks/dust, rocks with cavities, rocks with fractures.
- Handles analysis of random "challenge rocks" not clearly classified in previous image database.
- Sensitivity slider and/or other GUI controls for manually adjusting the analysis, as determined as the project progresses.

If successful, this software tool will be used to post-process every dust removal development test. The efficiency increase will result in a higher volume of testing, and better performance of the dust removal system on Mars.

Knowledge, skills, and expertise required for this project:

- Experience with MATLAB, as well as potentially relevant languages like Python and C++. Final determination of language and platform will be decided as part of early design.
- Some familiarity with image analysis will be helpful. The client can provide pointers to appropriate resources.
- Some familiarity with linear algebra. Again, the client can provide some technical pointers in this area.

Equipment Requirements:

- MATLAB. Many of our existing tools are written in MATLAB. (Note that NAU has a MATLAB site license)
- Client will supply a collection of images and any relevant camera and test setup parameters.

Software and other Deliverables:

- A complete software product as outlined above, fully tested, and installed on a platform of client's choice.
- Users guide to running the code, appropriate for someone with little software background.
- A strong as-built report detailing the design and implementation of the product in a complete, clear and professional manner. This document should provide a strong basis for future development of the product.
- Complete professionally-documented codebase, delivered both as a repository in GitHub, BitBucket, or some other version control repository; and as a physical archive on a USB drive.

This research will be carried out in partnership with the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.