Impact Breccia Composition and Glass Clast Analysis Tool

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Progress Report 1

1 Overall Project Description

1.1 Description

Analyzing the texture of a breccia sample formed by meteorite impacts can reveal information about how the breccia was created. When breccias form, the interior may not be uniform and will instead be filled with glass clasts (clumps of darker material). Figure 1 shows a breccia sample featuring several glass clasts. Analyzing the size, quantity, and shape of each glass clast is a very time-consuming process when performed manually, which is why geophysicists use software (eg: ImageJ) to semi-automate this process. Our project is to create an application that works in conjunction with ImageJ, further automating the process of analyzing glass clasts in recovered impact breccia samples.

Figure 1. Breccia sample featuring glass clasts.

ImageJ is an open-source scientific imaging application that is used across the scientific community. ImageJ features a wide range of image processing tools that the Earth Sciences department uses to isolate the glass clasts of a breccia image. Figure 2 shows Figure 1 after processing it through ImageJ.

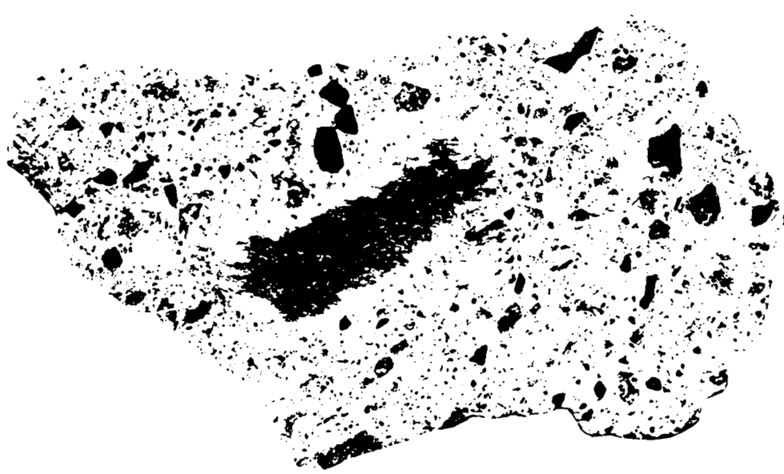

Figure 2. After sending an image into ImageJ for processing.

The main goal of our project is to improve the process of how the Earth Sciences department utilizes ImageJ to analyze breccia sample images. Dr. Osinski has identified that the main problem with the process of isolating glass clasts is the time spent manually adjusting the image after it has been processed by ImageJ. The images produced by ImageJ still require manual touchups around each isolated glass clast. Clast edges must be adjusted, holes must be filled in, and invalid/incorrectly identified clasts must be erased, as seen in Figure 3. The manual adjustments can take several hours, and our project hopes to reduce the time spent adjusting each image by improving the initial output and automating the work currently done by hand.

Figure 3. After manual adjustments of ImageJ output.

Before a sample can be processed by ImageJ, it must undergo contrast adjustments, hue adjustments, Gaussian blur filtering, background removal, etc. After these adjustments have been made, the RGB channels are split, resulting in three monochrome images. The resulting image that best showcases the glass clasts is then chosen for further adjustments. This pre-processing pipeline is the combination of many image filters, and our project aims to semi-automate the process of applying each pre-processing filter by developing a reliable black box approach of image pre-processing. Once image pre-processing is complete, main processing begins. In main-processing threshold values are adjusted and despeckling is applied to isolate each glass clast.

Post-processing is performed once the user is satisfied with the results of the main processing. In post-processing, the user must manually adjust the edges of each clast to remove unwanted segments. Post-processing is the most time-consuming aspect of image processing, and the core goal of our project is to reduce the time spent in manual image post-processing.

The development of algorithms to perform better image processing is the main component of our project. Our algorithms will work in conjunction with ImageJ to provide a clean interface for researchers to use when analyzing images. Our project will also focus on the output of results. In addition to improving the image processing pipeline, our project will also create tables, graphs, and charts to automatically present data gathered from the finalized image.

1.2 Context Diagram

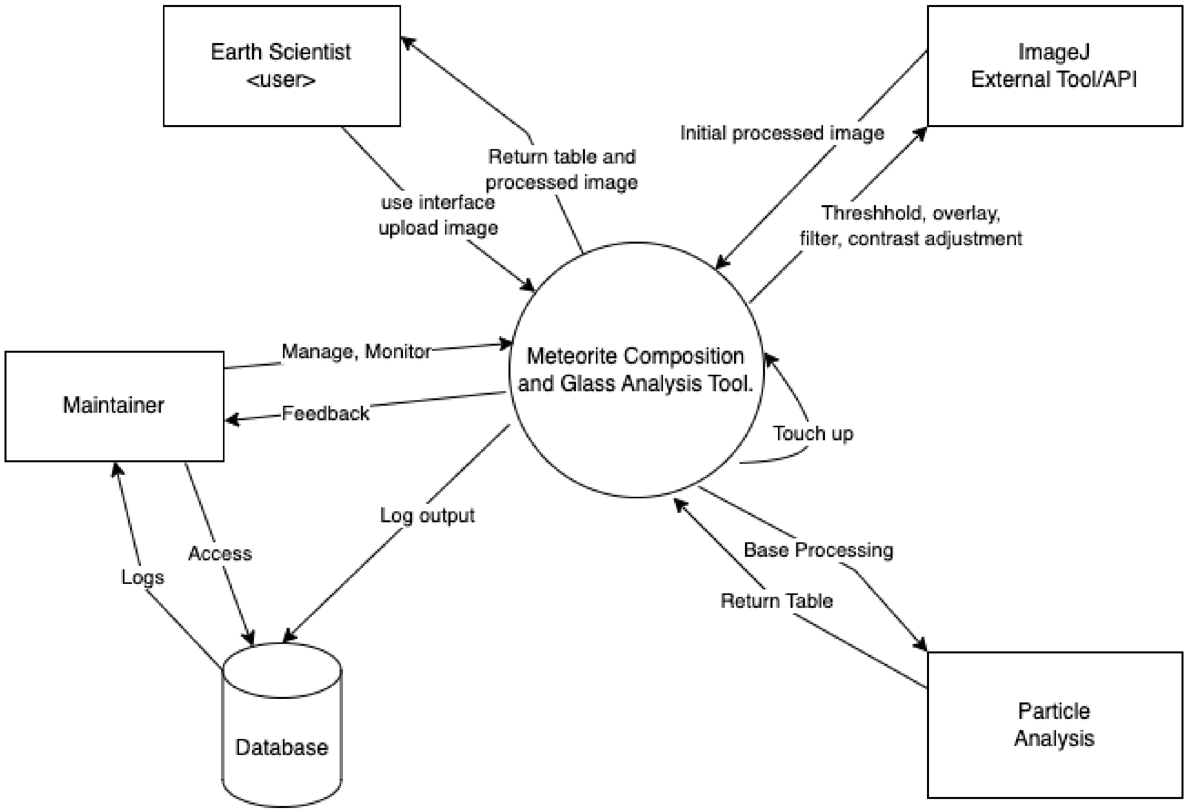

Figure 4. Impact Breccia Composition and Glass Clast Analysis Tool Context Diagram

2 Project Goals and Objectives

2.1 Goal

To develop a system that streamlines the process of identifying glass clasts in impact breccias through image processing filters that identify glass clasts and remove background filler.

2.2 Objectives

- O1: Collaborate with Dr. Osinski and his students to refine the system based on their practical use cases and requirements.
- O2: Develop an algorithm for pre-processing adjustment of filtering, contrast, and background subtraction of rock sample images using ImageJ to enhance visual clarity, and split the image into red, green, and blue channels.
- O3: Develop algorithms for main-processing adjustment of threshold, and despeckling of rock sample images using ImageJ to isolate glass clasts.
- O4: Develop algorithms for post-processing of rock sample images (remove outliers, image overlay, touch up, set scale) using ImageJ to enhance visual clarity.
- O5: Integrate the developed algorithms into a desktop application that is available on Windows and Mac.
- O6: Implement a clean interface for users to adjust the execution of certain analysis algorithms.
- O7: Design a pipeline for automated image processing.
- O8: Ensure that the UI allows researchers to easily navigate and execute the entire analysis workflow.
- O9: Implement error-checking mechanisms within the application to identify and handle potential issues during the image processing pipeline.
- O10: Conduct thorough testing and validation of the automated image adjustments to ensure their effectiveness across a diverse set of breccia samples.
- O11: Optimize the algorithm's performance to achieve real-time or near-real-time processing speeds for improved efficiency.
- O12: Provide comprehensive documentation for users, including tutorials and guidelines for effectively utilizing the desktop application and its features.
- O13: Distribute the system to users outside of the Western Earth Sciences department.

2.3 Significance

The process of analyzing the glass clasts in impact breccia samples is important and time-consuming. Current approaches use ImageJ to semi-automate the analysis process, however, several hours of manual adjustments are still required afterward to produce a usable image. Our project would significantly reduce the time spent by geophysicists editing images and would create results that are more accurate than current software. Dr. Osinski is interested in releasing our system to the public, which would allow our work to benefit the broader scientific community.

3 Roles

Project Manager	**Nicolas Jacobs**
Liaison	**Nicolas Jacobs**
Programmer	**Nicolas Jacobs** **Yuhan Zhang** **Yifei Zhang**
Documenter	**Nicolas Jacobs** *Yifei Zhang* *Yuhan Zhang*
Quality Analysts	**Yuhan Zhang** *Yifei Zhang* *Nicolas Jacobs*
UI\UX design	**Yifei Zhang** *Yuhan Zhang* *Nicolas Jacobs*

NOTE: **Lead** *secondary*

4 System Requirements

See System_Requirements.xlsx document

5 Project Plan and Tracking

5.1 Chart

See PR1_Project_Plan_and_Tracking_Chart.pdf for an overview of the full sprint plan.
See Sprint1.pdf, Strint2.pdf, Sprint3.pdf, and Sprint4.pdf for a detailed view of each individual sprint.

5.2 Spreadsheet

See PR1_Project_Plan_and_Tracking_Spreadsheet.xlsx

References

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[2] Alexis David Pascual. *Autonomous and Real-Time Rock Image Classification using Convolutional Neural Networks*. Electronic Thesis and Dissertation Repository, 2019, No. 6059. Available at: https://ir.lib.uwo.ca/etd/6059.

[3] R. J. Lisle, P. Brabham, J. Barnes. *Basic Geological Mapping*. 5th edition. Wiley-Blackwell, 2011.