

# VIPER Rocks!

## Senior Design Final Report

California State University, Los Angeles

9/1/2023 - 5/3/2024



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# 1. Introduction

## 1.1 Background

The Jet Propulsion Laboratory is a renowned institution at the forefront of space exploration. The organization is managed by the California Institute of Technology (Caltech), and is operated under contract by NASA which provides funding for the oversight of space explorations and scientific research. The project, Viper Rocks! was initiated in collaboration with California State University, Los Angeles and NASA's Jet Propulsion Laboratory (JPL), which serves as both the customer and sponsor. The senior design capstone project from this university highlights the potential collaboration with university students under the guidance of industry mentors and an academic advisor. It also showcases individuals problem-solving skills, management skills and technical expertise when addressing complex challenges and providing solutions to complete the technical projects.

Our VIPER Rocks! project, aims to develop a user-friendly web application for scientists, researchers and citizen scientists. It will provide a platform that assists with analyzing and categorizing lunar rock data efficiently. Thus making it possible to advance our understanding of lunar geology and support future space exploration missions. The challenge we aimed to address came from the complexity of analyzing lunar rock data being collected during the tasks of scouting, sizing and classification. Therefore, the requirement of having a comprehensive web application that could process the images and quantitative data was essential to facilitate the collaboration among scientists, researchers, and citizen scientists.

To achieve our goals, individual team members made significant contributions to various aspects of the project. We are divided into Backend and Frontend teams allowing for efficient progress and timely delivery of project milestones. In the Backend, we addressed challenges like creating a secure, scalable system for user management and data storage, integrating third-party authentication, and implementing features such as email verification. The Frontend team focused on designing a visually appealing user interface for tasks such as scouting, sizing, and classification, which involves complex image manipulation.

## 1.2 Design Principles

Throughout the development of the Viper Rocks! web application, our primary focus was on prioritizing key design principles to ensure an optimal user-experience. When comparing existing solutions they often lack user-friendliness, which hinders efficient analysis and categorization of important scientific data. Therefore, the principles included in our website are user-friendliness, accessibility, mobile/desktop responsiveness, performance optimization and adherence to the JPL website design guidelines. By centering our design approach around these fundamental principles, we aimed to create a platform that offers a simple and interactive experience for users, regardless of their devices or accessibility needs. Our goal was to establish

inclusivity for individuals with disabilities and empower users to contribute to scientific research on lunar geology and support future space exploration missions.

### **1.3 Design Benefits**

The design of the website offers numerous benefits to both users and stakeholders. First, its user-friendly interface enhances usability and engagement, allowing users to navigate through the web pages and participate in each lunar exploration task with ease. The emphasis on accessibility ensures that there is inclusivity, enabling individuals with disabilities to access and interact with the platform more conveniently. The mobile/desktop responsiveness design is incorporated to accommodate users on a wide range of devices, from smartphones to laptops. In addition, performance optimization ensures a quicker page loading time and seamless interaction, enhancing the overall user experience. Finally, adherence to the JPL website design guidelines maintains consistency and professionalism. It reinforces credibility of the platform and aligns it to the established standards in the scientific field.

### **1.4 Achievements**

For this project, we were successfully able to make the project run with its core features, as mentioned the basic three core features that form the basis of this project are scouting, sizing and classification and out of the three of them, we were successfully able to deploy two of them- scouting and sizing. For classification, it is somewhat done but needs more work to be completely done. By using different tools by the backend and frontend team, we were also able to achieve data security, integrity, and develop a user-friendly with efficient user interface. Experiments have shown statistical/image outcomes in both the user screen and the database being managed by the undergraduate students and liaisons. These testing results indicate the success of task functionalities and usability of Viper Rocks! ensuring that all intended requirements are being met.

## **2. Related Works and Technologies**

### **2.1 Existing Solutions**

Upon reviewing existing works that attempted to solve the same problem, it was notable that none of them offered integration of scouting, sizing and classification tasks within a single comprehensive platform. Existing solutions did implement various tools and methods for image processing algorithms for rock detection as well as classification techniques for shape categorization. However, this created an absence of having a cohesive workflow between each lunar rock analysis task. Without these essential functions, scientists and researchers depend on separate software applications and manual methods. Therefore, resulting in inefficient and constrained data analysis. In comparison, Viper Rocks! addresses these concerns by providing a unified platform with the three main rock analysis tasks; scouting, sizing and classification. The website also facilitates collaboration which contributes to accelerating the lunar scientific discoveries.

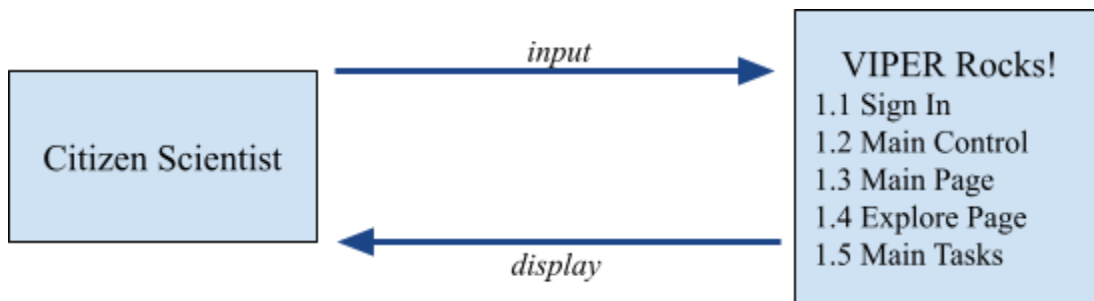
### **2.2 Reused Products**

As university students undertaking the development of the web based application, we meticulously selected technologies that would best suit the project's requirements. We incorporated the technologies of React, Next.js, Konva, Prisma, Vercel, PostgreSQL, PostGIS, QGIS and SQL. React was chosen for the front end development, Next.js for server-side rendering, Konva for complex image manipulation, and Prisma for database access and management. Vercel was chosen for the deployment of the web application, and PostgreSQL with PostGIS are utilized for spatial data management. Furthermore, integrating QGIS and SQL allows us to enhance the geospatial analysis and data querying.

# 3. System Architecture

## 3.1 Overview

The Viper Rocks! web application framework is built to facilitate citizen scientist participation in NASA’s research on lunar rocks. The design is centered on several key modules and components to achieve the system’s primary goals: crowdsourced rock scouting, sizing, classification, data collection and aggregation, and scientific discovery. The system ensures secure user access through a resilient login system and management of user information. Data communication and management are handled within a secure network environment, while citizen scientists complete the rock-related tasks. Administrators for the web application have access to data analysis and management tools. Further utilities listed for the system architecture are explained below and support the web application function; including data storage, user management and communication for collaborative tasks. The architecture shown below is the Level 0 and Level 1 Data Flow Diagram which outlines the interactions between the users and system components.



**Figure 1.** Level 0 Data Flow Diagram

**Sign In:** The sign in feature is responsible for managing user authentication and access control. Users can register for an account and securely log in to the platform, verifying their identity and granting them access to the system’s functionalities.

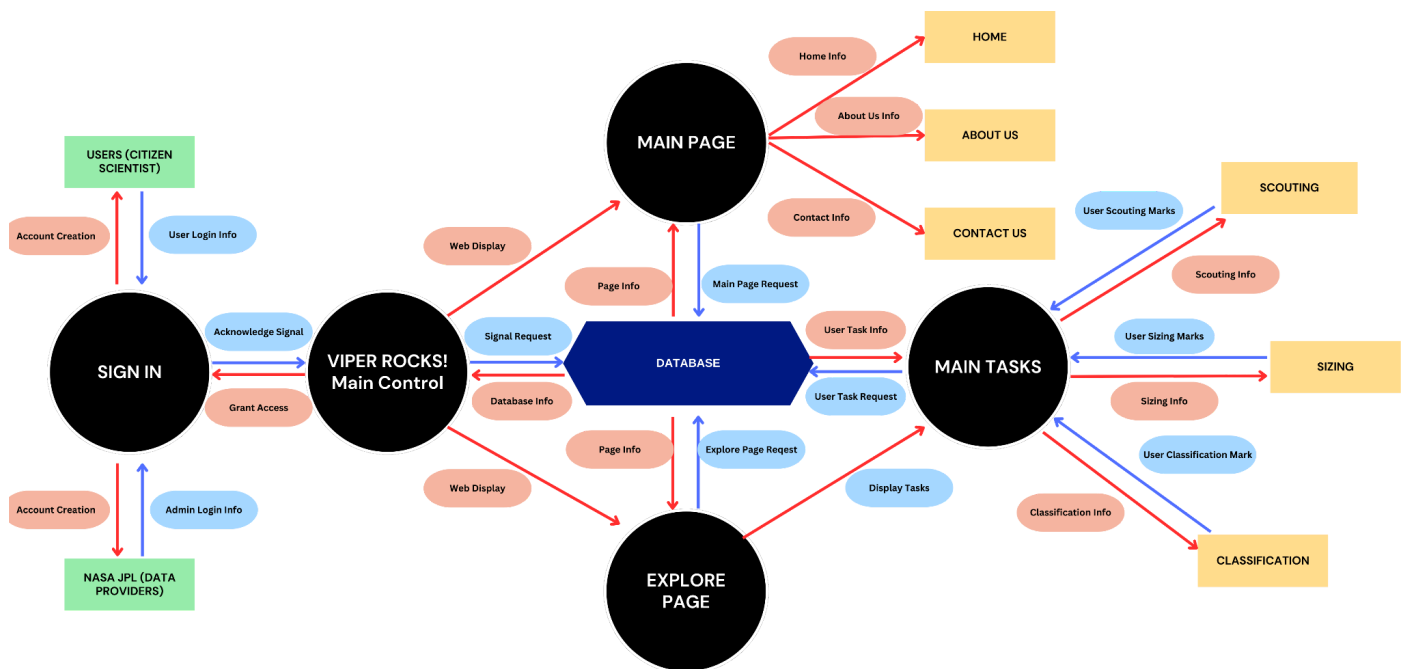
**Main Page:** The main page serves as the starting point for navigation and exploration of the web application. This page provides users with an introduction to the website and easily access information about space exploration and features. It contains a toolbar at the top for users to easily navigate to the Home, About Us, and the Contact Us page. This page also includes an explore button that directs users to the three main tasks; those being scouting, sizing and classification.

**Explore Page:** The explore page presents users with an overview of the available tasks that lead to different rock image processing tasks; scouting, sizing, and classification. This allows individuals to browse and select tasks based on their interests or expertise.

**Viper Rocks! Main Control:** The viper rocks! main control serves as a central processing unit responsible for coordinating requests and responses throughout the system. It facilitates communication between various modules, components, and the database.

**Main Tasks:** The main task is responsible for being the central interaction point for completing tasks related to lunar rock analysis. It involves the three different rock image processing tasks: scouting, sizing, and classification.

### 3.2 Data Flow



**Figure 2.** Level 1 Data Flow Diagram

**Home Page:** The home page shows users relevant information such as announcements, space exploration news, features content of future events, and navigation links to other sections of the website.

**About Us Page:** The about us page provides users with information about the web application, its purpose, mission, history, team members, and any other relevant details.

**Contact Us Page:** The contact us page facilitates users' accessibility and communication with the website administrators, scientists, or other relevant contacts for inquiries, feedback or support to navigate and complete the required tasks.

**Database:** The database is responsible for storing, managing, and retrieving all data required for the system's operation. It stores various types of information, including user profiles, rock images, task results and administrative data.

**Scouting:** The scouting task explores various images to determine an approximate number of rocks. Citizen scientists are able to estimate the quantity of rocks in an image by selecting from predefined options.

**Sizing:** The sizing task uses subdivided images from the scouting task. Citizen scientists are able to utilize a sizing tool to measure various rocks.

**Classification:** The classification task enables citizen scientists to classify the shapes of individual lunar rocks into categories such as angular, sub-angular, sub-rounded, and rounded.

### **3.3 Implementation**

For the implementation of this project, there are two major teams to work on the frontend and the backend part of the project. When it comes to implementation the main features would be developing a database to store, access and retrieve user data and use that the data for useful information after and then connecting the database to the front end part of as well so the user would be able to retrieve and see what they have been doing using the main features developed for the project that include scouting, sizing and classifying these rocks. On the webpage, every user needs to sign in with an account to verify their identity and track their activity later as well.



## 4. Results and Conclusions

### 4.1 Results

During the Fall 2023 and Spring 2024 academic terms at California State University, Los Angeles, the entire team of ten undergraduate students successfully developed the Viper Rocks! web application. Despite encountering numerous challenges and complexities, our team demonstrated exceptional commitment, collaboration, and creativity. By leveraging our collective expertise in Computer Science, we were able to assist each other to create this initial web application design for the upcoming JPL project. The project-based learning approach at the university allowed us to gain insight into real-world experiences and initiate a software design that would be meaningful to scientific research and innovation.

Several aspects of the project were successful. First, the implementation of a secure user access system enforced authorized user participation while protecting sensitive data. Second, achieving the integration of the main task features of scouting, sizing and classification was another aspect that succeeded. This demonstrated the team's ability to provide a functional coding foundation within the project's timeline and for the use of future students within the field. Third, when conducting tests, the web-application returned statistical and image outcomes that conveyed the system was functioning as intended. Overall, these findings showcased the capability of the Viper Rocks! website and its potential to extend these lunar discoveries with the collaboration of the community.

Despite the success, some challenges were encountered during the implementation process. A notable area that faced challenges was the deployment of the classification task. The ability to classify the shapes of individual rocks on the Moon by choosing the best match from a provided list needed further refinement and development to achieve full functionality. While scouting and sizing functionalities were successfully deployed, the information from the sizing task is currently unable to determine the boundaries of an individual rock. This impedes the advancement of following through to the classification task and being able to select if the rock is angular, sub-angular, sub-rounded or rounded.

## 4.2 Future Development

To successfully implement each goal of the Viper Rocks! website individuals need to follow-up with additional research to implement additional features not already given in the code file for the website. Addressing the remaining challenges in the classification feature is crucial to realize the platform's full potential. Upcoming students who are involved in the Viper Rocks! projects may need to refine the algorithms, optimize the image processing techniques, and enhance the accuracy of classification task results. Also, keeping up with website maintenance and updates will be necessary to ensure that the platform remains secure, user-friendly, and aligned with the evolving scientific standards and guidelines. Lastly, of utmost importance continuing the collaboration and communication with the liaisons, including NASA and citizen scientists is vital to further advancements. This will be beneficial to ensuring the platform's relevance and effectiveness in supporting future lunar explorations.

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