

Project Report

for

MoonTrek Telescope

Version 1 Approved

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1.0 Introduction

- Sponsored by NASA Jet Propulsion Laboratories and modeled after NASA MoonTrek, a web portal developed to meet the needs of mission planners in a new era of lunar exploration, with the intention of being more easily accessible and user friendly. Our MoonTrek application will bridge the gap between a user provided telescope image and anyone's smartphone or laptop. It will allow anyone interested to explore the moon with ease providing amateur astronomers ample information to nurture their love of space.
- A general challenge faced throughout the development of this project was the inaccessibility to campus where we were supposed to have the ability to use a telescope.
 - The advisor of our project allowed for us to use one of her personal telescopes one at a time to pass from teammate to teammate.
 - A unique achievement of this project includes receiving a user provided image from a telescope, after which application programming interface (API), calls can be made and data layer information can be added which will be used to supply the user with information and facts they may not have known about the image they submitted.
- There are 3 main group sections including our 3D team, 2D Circle detection team, and our User Interface team. In conjunction to this, each member had their own roll including;
- 3D Team
 - Nicolas Ojeda: Team Lead
 - Kevin Aguilera: Development (Graphics Model)
 - Gerard Rosario: Front End Graphics Lead
- 2D Circle Detection Team
 - Elvira Sakalenka: Computer Vision Lead
 - Jacob Fausto: QA/Testing Lead
 - Alex Lamb: Communications Lead
 - Dakota Townsend: Documentation Lead
- User Interface Team
 - Albert Ramirez: Lead Backend Developer
 - Pavit Chawla: User Interface Lead
- The idea of modeling our project after the NASA Moon Trek was to create a more user friendly portal for it to be used by more amateur astronomers or anyone that took an interest in the moon. The idea was to create a similar tool to be used by someone who may know less about what they are looking at or looking for and to provide a fun easy way to learn more about the moon.

- This project is separated into three parts that will all come together to provide functions and produce results similar to NASA MoonTrek's. The first part of this project was creating a user friendly and efficient interface which will be accessed on any laptop or smartphone through a web browser. The second part of this project revolves around image registration, this part takes the user provided image and identifies the parts of the image that are the moon. The final part of this project includes producing a 3D model which will be implemented in the back end to correct distortions between the image and the data layer information to provide the most precise and reliable results possible for the user
- Some design benefits include;
 - Designing a user friendly, efficient, and intuitive UI that encourages amateur astronomers to cultivate their curiosity of the moon.
 - Developing a user interface that bridges the gap and serves as the connection between the backend development, telescope, and user.
 - The application is an extension and user friendly version of the existing NASA MoonTrek portal which promotes the education of the moon to a wider range of interested parties.
- Software testing will occur during the development of the software, as the team will need to constantly ensure that API's used for calculations within the code are behaving as expected. Also, when compiling/running the code in a testing environment, we will expect the desired images loaded on the screen. We are, however, constantly testing our results using testing data like images of the moon provided to us by NASA JPL to ensure consistency. From our testing we have been working toward optimizing our accomplishments to improve run time for speed of use so that the user is not waiting long periods of time to see the information about their submitted image. We have been experimenting with parameters and code to improve our solutions so that it runs with the best performance achievable.

2.0 Related Works and Technologies

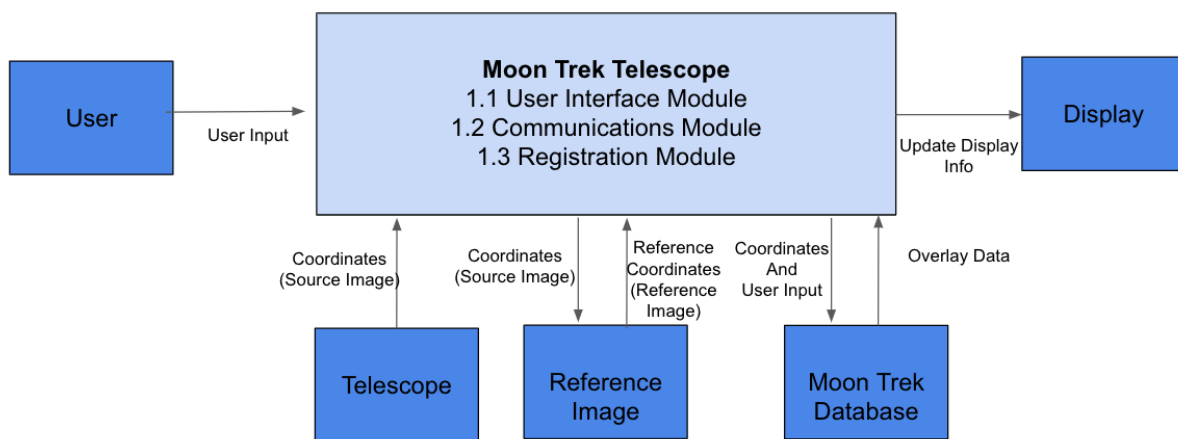
- Our solution has similarities to the already established Moon Trek portal made by JPL. What makes our application unique and different is that the images that will be annotated, the features and information provided, will be solely on the user-provided image and not an already established image of the moon. This means that the images of the moon provided to our application will always be different in size, shape, color, etc. As we account for these factors the main goal is to be able to annotate that image that the user provides.
- The decision to use OpenCV was made early on because it is a commonly used cross-platform library that is primarily used for object detection and image processing. This also led to the decision to use an older version of Python due to our need to use the SIFT algorithm which was only available on previous versions of OpenCV. The SIFT

algorithm is an algorithm used to detect and describe local features in digital images that propelled the success of our project forward.

- By using specific versions of these softwares we were able to successfully execute a major focus of our project. Image registration and circle detection were an outstanding focal point of the Moon Trek Portal we created and served as the nucleus of our entire project.

3.0 System Architecture

- Describe system architecture. (Include DFD graph).

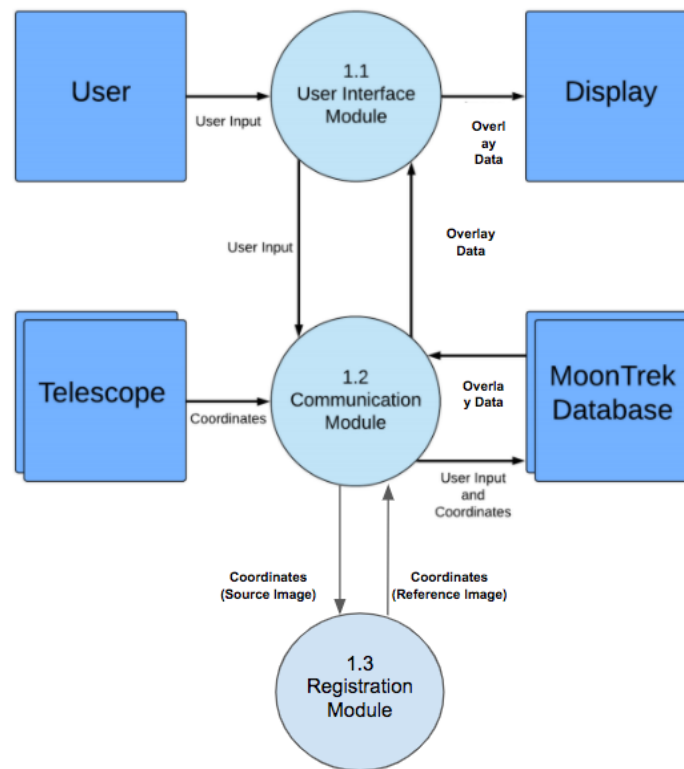


DFD Level 0

- The two main modules of the Moon Trek Telescope are the User interface module and the communications module . The user interface module is in charge of displaying the information gathered from JPL's database . This information can be annotations or overlays relative to the graphical coordinates of the moon present in the users view . The registration module will be in charge of properly locating each coordinate in the source view of the moon to the reference image of the moon . The communications module would allow us to reach the JPLs datasets of the moon and fetch them to use them in our user interface module.
- Software/Algorithm/System Development and Implementation;
 - The application will take into account image registration of the image provided by the telescope . The design of the software needs to include an architecture that will register the image while fetching data once after the image is registered . The front end will just shoot the image of the moon routed from the telescope , while the back end will be executing several processes . The design will require to

implement these processes at rapid speed so the main feature of adding overlays can be executed as fast as possible.

- The processes in order will be such as;
 - Route image into browser/application view
 - OpenCV circle detection on the moon
 - Image registration of source image and reference image
 - Recreate an image of the moon that closely resembles the source image
 - Image recreated will contain
 - LRO WAC Mosaic map of the moon from JPL
 - Right shape of the moon that closely resembles the source image
 - Right shadow and light from sun .
 - Image recreated will be a snapshot of a 3D model of the moon. The reason we create this reference image and the way we do it is to get rid of geometric distortion that otherwise would be present in just registering to the LRO WAC Mosaic of the moon from JPL's Moon Trek portal .
 - Once each pixel coordinate of the image from the telescope(source image) is located in the LRO WAC Mosaic 3D model snapshot (reference image) , the application will be required to fetch data of the moon regarding those specific coordinates of the moon in the source image .
 - Data to fetch will be such as ;
 - Temperature data
 - Chemical makeups of soil data
 - landing sites data
 - Rock abundance data
 - etc .
 - This data will be saved in a Pandas data frame to then be used in the front end of the application in a certain way.



DFD Level 1

- The system is composed of mainly three modules ; user interface , communications and registration module . The main modules doing the work are the communications and registration modules .The telescope image will be provided to these modules and execute important tasks . Image from the telescope will be passed to the registration module where all image registration procedures will take place . The right coordinates will be generated and then passed back to the communication module . The communication module will fetch overlay data with the correct produced coordinates implemented from the registration module. Then the data will be passed to the user interface module in order to display it to the users view of the moon.

4.0 Results and Conclusions

- To be able to accurately annotate the users' specific view of the moon we perform image registration on the user provided image to properly locate each point of that image. We worked in partnership with NASA's JetPropulsion Laboratory (JPL) to gather important moon data. Our image registration is performed using the user's moon as a source image and using an already mapped moon image from JPL as our reference image. The first step is to properly locate each point on the user's image on the JPLs map of the moon. Once

this is performed, registration is done and we can reference any point in the users' image of the moon. The second step is to gather all interesting data in relevance to that specific view of the moon and present this data in our application in an interesting, interactive, and fun way.

- Over the course of two semesters, we have accomplished creating a website that connects all mentioned teams work into one final product. We achieved creating the server to extract image coordinates, applying image registration, and creating an accurate 3D model to present the Moon Trek database's information effectively through our website. Additionally, our website allows the user to view specific coordinates and craters of the moon with the well-defined precision.
- As for following steps to continue this project, the main focus would be to actually have access and work with the telescope on campus at CSULA. Unfortunately, due to the pandemic over the course of the last year, we had to shift goals a little bit. So having access with the telescope on campus and being able to use the telescope and adapt our MoonTrek Portal to actively use real-time image registration for annotating images of the moon would be a very exciting and interesting progression of our project.

5.0 References

- Macias, Jose Recommended Template for Software Requirements Specifications
- ASCOM Standards <https://ascom-standards.org/>
- MoonTrek API: <https://trek.nasa.gov/tiles/apidoc/trekAPI.html?body=moon>
- Django Web Framework: <https://docs.djangoproject.com/en/3.1/>
- OpenCV : https://docs.opencv.org/master/d6/d00/tutorial_py_root.html
- ThreeJS : <https://threejs.org/docs/>