# Lunar Crater Detection and Recognition

**Team Members:** Natalie Gallegos, Tony Liang, Marvin Mendez, Raul Ornelas, Alberto Serrano Jr.
**Graduate Advisors:** Saman Saeedi, Richard Cross
**Faculty Advisor:** Dr. Elaine Kang
**JPL Liaisons:** Emily Law, Shan Malhotra, George Chang
Department of Computer Science
College of Engineering, Computer Science, and Technology
California State University, Los Angeles

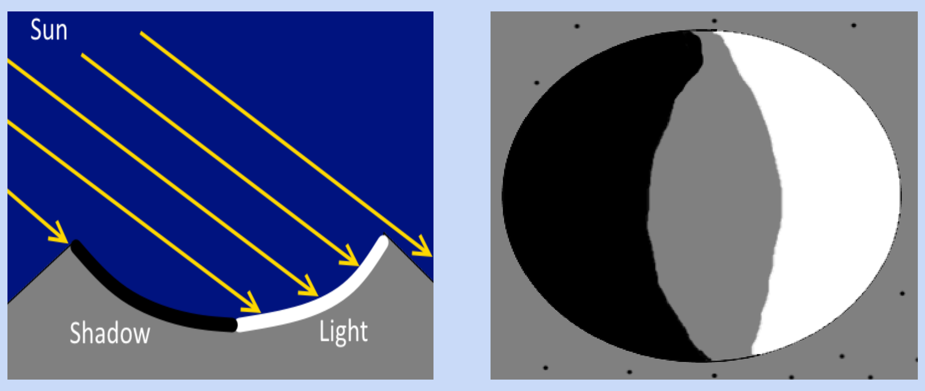
## Background

Crater detection is an important task for many space exploration missions. Crater detection is used for a number of applications, including mapping celestial bodies, hazard detection, and updating spatial and temporal stratigraphy and topography of the body in question. Resources for crater detection are limited, and new approaches or methods are always welcome.

## Objective

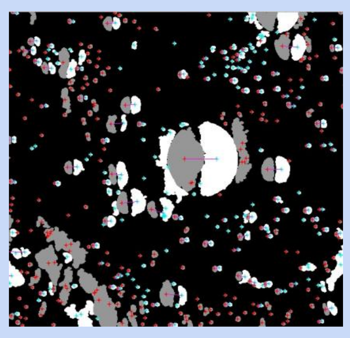
The Lunar Mapping and Modeling Portal (LMMP) team at JPL tasked our LCDR team to develop an algorithm that will automatically detect lunar craters using images from the Lunar Reconnaissance Orbiter Camera (LROC). Final program should estimate the shape of the crater, as well as the crater's approximate depth and diameter.

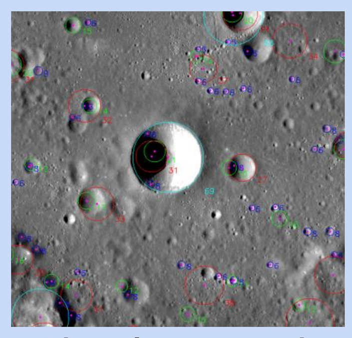
## What is a Crater…

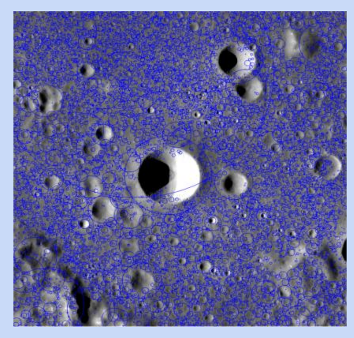


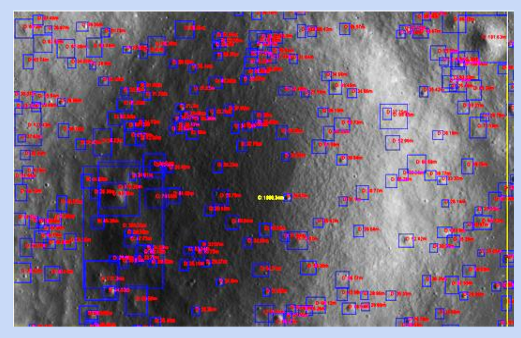

Craters are physical depressions in the surface of a planetary body. These depressions are characterized by circular and elliptical shapes and their images are comprised of light & dark patches, outlining the shape.

## Our Approach to Lunar Crater Detection


Dark & Light Pairing

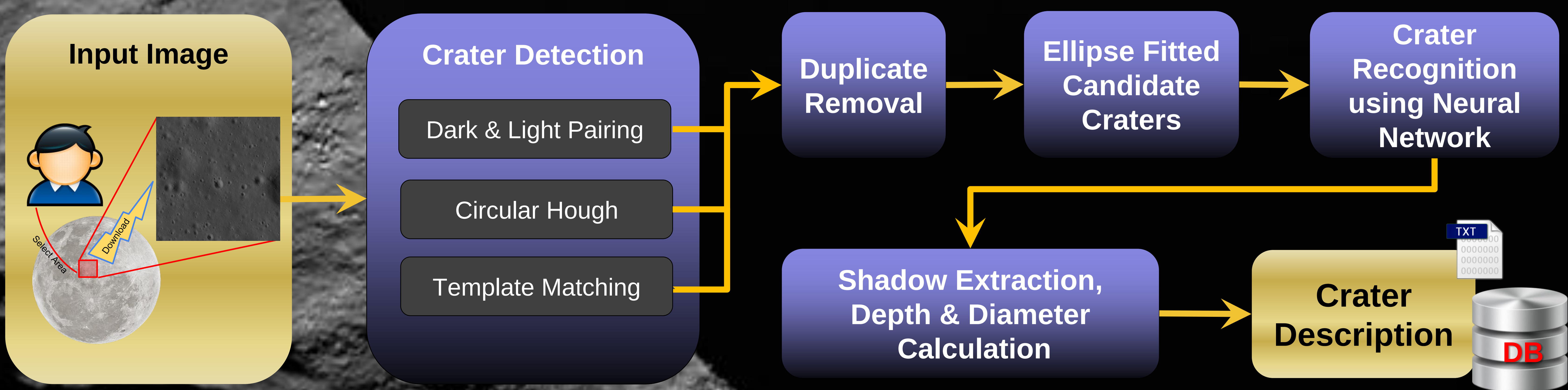

Circular Hough


Template Matching

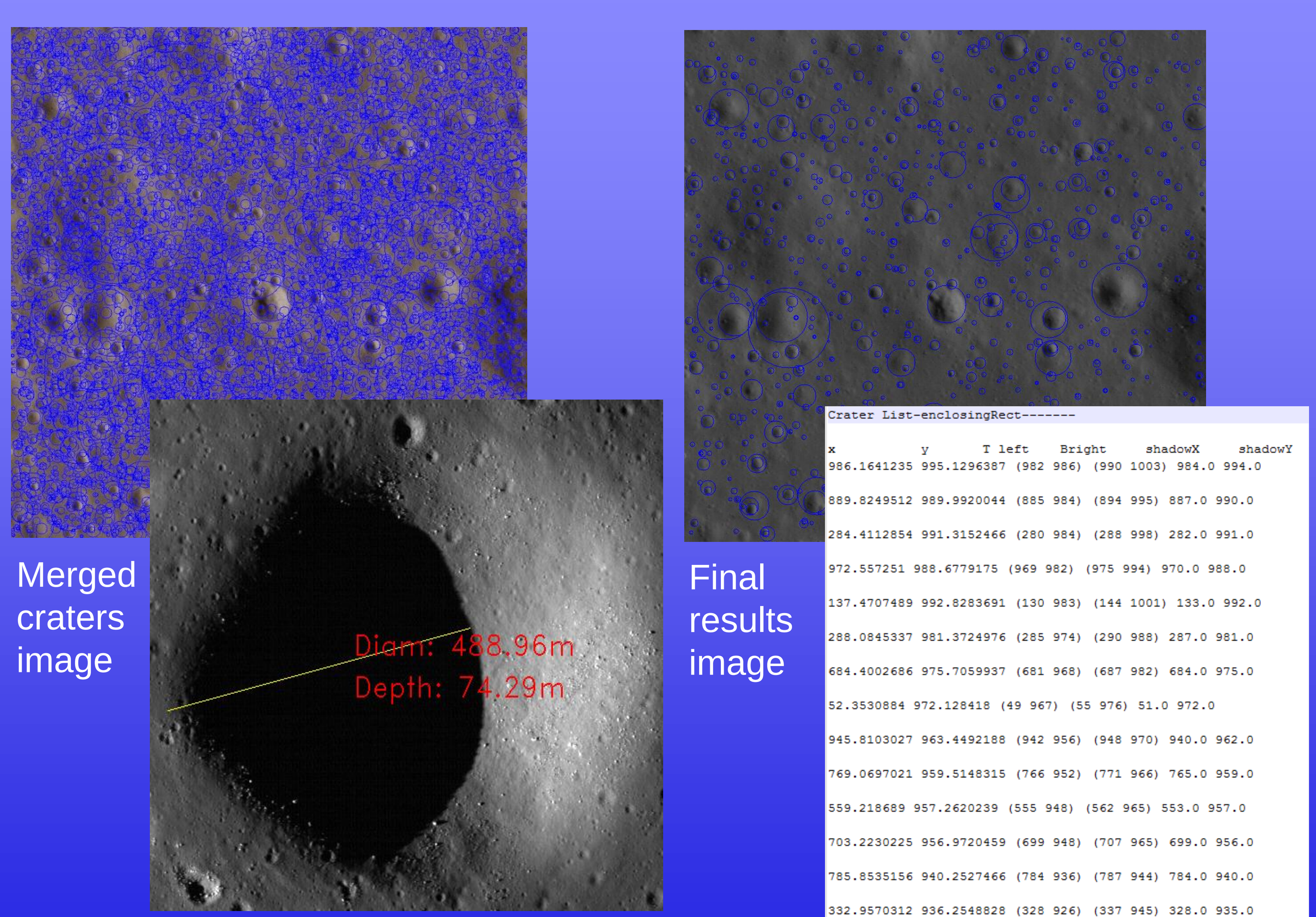

Crater Diameter & Depth

A user selects a region on the moon. *Ringtoss* then downloads an image from the LROC repository for the selected region of interest. This image is then processed by our three different detection methods. Each crater is added to a list, which undergoes further processing to remove duplicate detected craters. The list is then provided to a machine learning algorithm for improved detection and recognition. Finally, depth and diameter are calculated for each detected crater. Results are provided in text output and stored in a DB as well.

## RINGTOSS PIPELINE




## Ringtoss Results




Merged craters image

Crater Diameter & Depth

Final results image

Text results

## Conclusion

- Developed:
  1) Three different crater detection algorithms.
  2) A machine learning based crater recognition algorithm.
  3) A method to estimate crater shadow length, depth, and diameter.
- *Ringtoss* uses an efficient data structure (quadtree) to store and search craters; stores recognition results in text format, DB entries, and images; provides easy-to-use GUI to accept user's options.
- Comparable detection rate to JPL results:
  precision: 89.34% recall: 59.07% f1 score: 71.12%

Future Work:
Latitude & Longitude Interpolation; multiple image processing; incorporate the deliverables into LMMP http://lmmp.nasa.gov

**Development Tools** (Libraries, Languages & Sources)

OpenCV MATLAB Java Octave MySQL GDAL LROC