Mechanical Engineering Summer Research Program 2021

Maria Ortiz – Advisor: Dr. Jason Rabinovitch, Rabinovitch Research Group

Image Processing Methods and Applications in Mars Perseverance Rover Data Collection

Introduction and Objective

Following the landing of NASA's Mars Perseverance Rover, countless new research possibilities have been opened by the returning footage and images of the entry, descent, and landing process. These images included a never-before-seen view of the rover's parachute during inflation. Determining the parachute's size and change in position above the rover over time would allow comparison between its theorized behavior and the results seen. To date, the following progress has been made to reach this goal.

Important Algorithms and Program Outline

- Objective: import raw Mars 2020 rover image, find projected parachute area
  - View raw images: https://mars.nasa.gov/mars2020/multimedia/raw-images/
  - Drag Equation: $F_d = \frac{1}{2}\rho u^2 c_d A$ requires projected area for calculation
- Python programming language, primarily OpenCV library
- Desired image imported, displayed
- Region of interest (ROI) chosen by user (cv2.selectROI – allows analysis of specific area, reducing noise and background input)
- Edge detection (cv2.Canny)
- Edges converted to binary image (cv2.threshold – creates binary (black and white, no gray) by evaluating pixel intensities at given threshold value)
- Contour outlines detected in binary image (cv2.findContours)
- Convex hull found (cv2.convexHull – draws smallest convex shape containing all contour points)
- Smallest circle containing hull found (cv2.minEnclosingCircle)
- Areas of hull and circle calculated
- Center point, maximum radius, and area values displayed

Results

- Final program able to separate parachute from surroundings
- Found approximate area of parachute at given point in time
- Found approximate center point, maximum radius of region containing parachute
- Consistent results with simple and efficient user interface component

Figures 1-3 (Top to Bottom): Primary Up-Look Camera 1, Example Images
Left to Right: Original, ROI, Cropped ROI, Edge Detection, Contours and Hull, Final Display
(images enlarged for easier viewing)

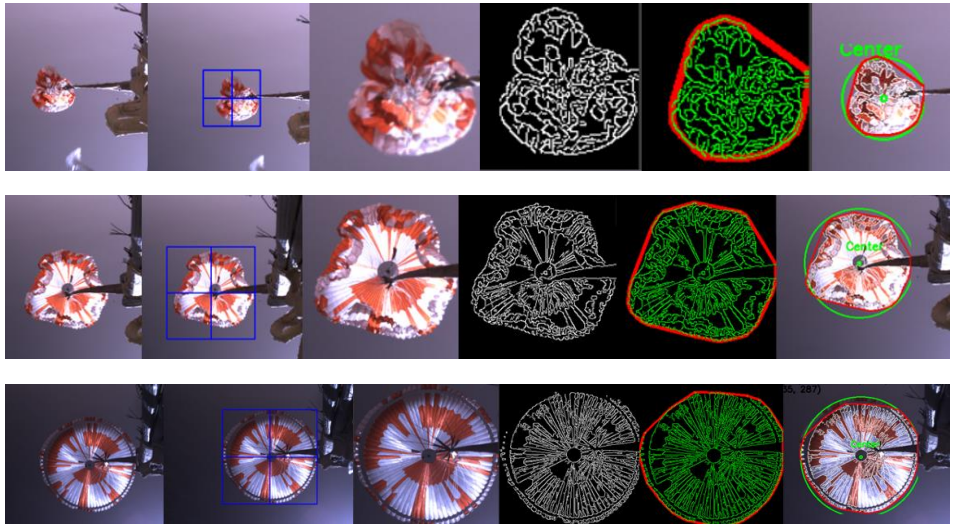
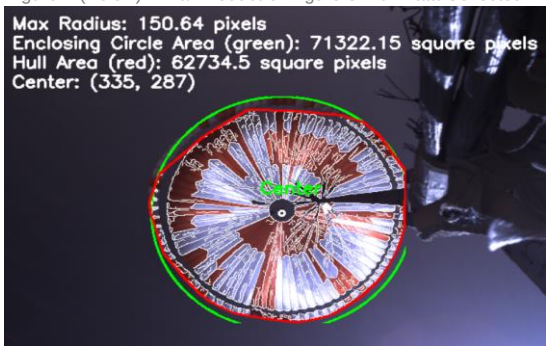


Figure 4 (Below): Final Product of Figure 3 with Data Collected



References

- Rabinovitch, Jason, et al. "Full-Scale Supersonic Parachute Shape Reconstruction Using Three-Dimensional Stereo Imagery." *Journal of Spacecraft and Rockets* 57.6 (2020): 1139-1152.
- Gupta, Bhumika, et al. "Study on object detection using open CV-Python." *International Journal of Computer Applications* 162.8 (2017): 17-21.
- Othman, Nashwan Adnan, et al. "An embedded real-time object detection and measurement of its size." *2018 International Conference on Artificial Intelligence and Data Processing (IDAP)*. IEEE, 2018.
- Balakrishnan, Jaya P. Geethu. "Contour based object tracking." *Red* 160.50 (2014): 179-250.

Conclusions and Future Work

- Progress summarized herein provides strong foundation for future analysis
- Able to determine desired data points for further analysis
- Moving forward, ideally more than one image should be analyzed at once
- Data saving methods should be evaluated to track size of parachute over time, degree of movement, and any rotation during descent
- Data points currently shown in pixel units should be converted to a usable metric