Using Machine Learning to Detect Chaos Terrain on Europa

Kathryn Gansler[1], Conor Nixon[2]

[1]*University of Maryland College Park, Department of Geology, 8000 Regents Drive, College Park, MD 20742, United States*

[2]*Planetary Systems Laboratory, NASA Goddard Space Flight Center, Mail Code 693, Greenbelt, MD 20771, United States*

Areas of Jupiter's moon, Europa, contain irregular ice floes that are illustrative of the massive disruption, reorientation, and refreezing experienced on Europa's surface as Jupiter's gravity imparts immense tidal forces that heat the moon. In recent years, various machine learning programs have been used to detect surface features on planetary bodies. Most commonly, such software works to count craters for estimating planetary surface age or to map sand-filled dune fields whose shapes may indicate wind or weather patterns. Creating software to automatically detect Europa's jigsaw-like ice floes will accelerate scientific analysis of such terrains once higher resolution images of the moon arrive in the fall of 2022 from the Juno spacecraft and later from the forthcoming Europa Clipper mission. In this project, a U-net, a deep learning semantic segmentation model, was applied to images of the surface of Jupiter's moon Europa taken by the Galileo spacecraft to detect ice floes in the moon's Chaos Terrains. To measure the quality of the program developed, the Intersection over Union (IoU), a metric that measures the goodness of fit for semantic segmentation, was calculated. Throughout the course of the project, the IoU increased from a value of 0.0012 to 0.286 by adjusting hyperparameters including learning rate and epochs. Adjusting how the data was labeled also improved performance, functioning best when ice floes were hand-labeled using loose-fitting polygons rather than exact edge-mapping. Additionally, the program was more effective for images with resolutions near 50 meters per pixel (mpp); the average image of Europa's surface to date has a resolution closer to 500 mpp. As Galileo faced transmission issues, the usable dataset was limited to 23 images, 19 of which were used for training and 4 for testing. In the coming months, higher quality augmented data should provide additional training images that should further improve the performance of the U-net. Once the algorithm is sufficiently capable of identifying floes in the Chaos Terrains, it may later assist in selection of regions of interest for further study on Europa or even landing sites for a future proposed lander.