Quantitative Hyperspectral Imaging Pipeline to Recover Surface Images from CRISM Radiance Data
PhD Dissertation Defense

Linyun He
PhD Candidate

Abstract: Hyperspectral data are important for remote applications such as mineralogy, geology, agriculture, and surveillance sensing. A general pipeline converting measured hyperspectral radiance to the surface reflectance image (single scattering albedo, SSA for short, is selected to describe the reflectance) can provide planetary scientists with clean, robust and repeatable products to work on. The Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) on the Mars Reconnaissance Orbiter (MRO) helps scientists understand the Mars surface. We mainly focus on developing a hyperspectral imaging pipeline for CRISM data. We introduce a general framework called STANN (Separating Temperature and Albedo using Neural Networks) to retrieve surface kinetic temperatures and surface single scattering albedos from spectral radiance data. STANN is derived using the Discrete Ordinates Radiative Transfer function to describe the forward model from SSA and temperature to radiance. This framework has been implemented for CRISM and the retrieved temperature has only 4 K error by one-point validation (242 K) from the Curiosity Rover. Retrieved from a radiance cube, a noisy hyperspectral SSA cube needs to be denoised and reconstructed onto the Mars surface. We propose a new algorithm, hypothesis-based estimation with regularization (HyBER), to reconstruct and denoise hyperspectral image data without extra statistical assumptions. The hypothesis test selects the best statistical model approximating measurements based on the data only. A regularized maximum log-likelihood estimation method is derived based on the selected model with both spatially and spectrally dependent weighting penalty. HyBER generates reconstructions with sharpened images and spectra in which the noise is suppressed, whereas fine-scale mineral absorptions are preserved. When applied to CRISM, the spatial resolution and contrast are about 2 times better as compared to map projecting data without the use of HyBER. So far, part of our results has enabled planetary scientists to identify minerals and understand the forming history of Mars craters. Outputs of the pipeline are consistent with measurements from the Opportunity rover and have informed decision processes regarding the path of the Curiosity rover and the landing site of a future rover.

Date: Monday, April 1, 2019
Time: 2:00 PM
Location: Green Hall, Room 0120

Dissertation advisor: Dr. Joseph A. O’Sullivan