Space Science Seminar
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Efficiently Sampling from Underlying Physical Models

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The capability and mobility of exploration robots is increasing rapidly, yet missions will always be constrained by one main resource: time. Time limits the number of samples a robot can collect, sites it can analyze, and the availability of human oversight, so it is imperative the robot is able to make intelligent actions when it comes to choosing when, where, and what to sample, a process known as adaptive sampling.

Current Mars rover operations give an example of the need for adaptive sampling techniques. Daily plans budget specific operations down to the minute, and each operation is given a maximum of a few hours to complete. However, the capabilities of the rover far exceed the limited plans. For example, the Mars 2020 mission is testing the Planetary Instrument for X-Ray Lithochemistry (PIXL), a spectrometer used to analyze rocks on a microscopic scale. A quick scan of a postage stamp-sized surface can take an hour but is very noisy, yet reducing this noise with a full scan of the surface takes multiple days. Scheduling constraints and communication delay prohibits scientists from reviewing data in real-time, but adaptive sampling techniques enable the rover to autonomously choose a subset of interesting points for detailed follow-up scans.

This talk addresses advancements in adaptive sampling for exploration robotics. Our work takes advantage of the fact that rover operations are typically not performed in a vacuum; extensive contextual data is often present, most often in the form of orbital imagery, rover camera images, and quick microscopic scans like those described above. Using this context, we apply advanced Bayesian and nonparametric models to decide where best to sample under a limited budget. We consider three main scenarios: selecting samples when given full contextual data, selecting samples with limited contextual data, and selecting a path of sampling locations given a fixed exploration budget and orbital imagery.

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