Planetary Lake Lander: Adaptive Science Initial Results

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Introduction

The Planetary Lake Lander (PLL) robotic probe, an analog to future probes on the lakes and seas of Titan, autonomously learns about its environment, and uses that information to focus its limited resources on the most relevant phenomena, improving science impact. Our general approach is to enable the robot to learn probabilistic models of the environment that improve over time, and use those models to sample at the most interesting times and places, downlink the most interesting samples, and further reduce data volume through smart compression.

Adaptive Depth Sampling

The lakelander sonde samples one depth at a time. Raising and lowering the sonde takes a significant part of the lakelander’s total energy usage. If the goal of sampling is to reconstruct conditions throughout the water column, what is the optimal sampling strategy?

A relevant insight is that some parts of the water column are more predictable than others. The largest temporal variations are often observed near the thermocline, a sharp temperature gradient marking the boundary between near-surface and deeper waters. This observation suggests a strategy of sampling more frequently at the less predictable depths near the thermocline, and carrying forward the predictable values at other depths using an environment model.

This concept was tested in simulation using historical data. Sampling strategies in simulation restricted to use less energy than was available on the real lakelander, thus could only collect a subset of the samples from the historical data set, and were evaluated on their ability to reconstruct the entire data set. Two strategies were compared (Fig. 5): The baseline strategy periodically took full profiles (samples at all depths). The adaptive strategy took less frequent full profiles and more frequent partial profiles centered on the thermocline. Using the adaptive strategy reduced the error of the temperature reconstruction from 1.22 C to 0.63 C (RMS). The adaptive strategy is now being evaluated onboard the lakelander.

Lake Lander Platform

The PLL lakelander is deployed at Laguna Negra in the Central Andes of Chile, at 2700 m elevation in the region of the Ecuarchaim glacier.

adaptive shore approach

The adaptive shore approach prioritizes downlink of data collected around their occurrence and follow up data collection.

Storm Detection

Storms are interesting due to their effect on lake processes. For example, precipitation runoff can increase nutrient inflow, and windstorms can blow silt into the lake. Storms may also be rare and important events in Titan lakes, enabling study of Titan’s methane cycle.

When the lakelander detects a storm, it responds by taking a burst of high-rate samples and sending an alert email to the science team.

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References


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