Understanding Human Decision Making in Robot-Assisted Field Data Collection

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Abstract:
Scientific field data collection requires expert scientists to mentally process and integrate a large number of observations and measurements, and dynamically adjust their scientific belief and sampling plan in response to incoming data. This fast-paced and tightly-integrated "information search" and "dynamic strategy adjustment" processes can place large cognitive burden on human experts and lead to limited exploration efficiency or misapplied heuristics. In this study, we present a Robot-assisted Field Sampling Decision Support Framework and demonstrate that with a better understanding of human decision making, our robots can begin to serve as intelligent assistants and provide human experts with statistics-informed decision support to enhance the efficiency of field data collection and help prevent potential decision biases.

To determine how data collection strategies are made based on prior knowledge, and how sampling plans are adapted in response to incoming data, we designed a novel simulated data foraging study, and collected dynamic sampling decision responses from 116 geoscience researchers. We found that there exists two primary information search modes: exploration, and verification. Sampling decisions during exploration are commonly dominated by information coverage within the variable space, whereas sampling decisions during verification are primarily driven by the discrepancy between hypothesis and measurements.

Based on our findings, we develop decision support algorithms that allow robotic teammate to infer humans' information search mode, and aid humans with the selection of sampling locations to enhance their information search objectives. During exploration mode, the robot integrates human-provided initial belief with dynamically-updated information coverage distribution, and suggests potential sampling locations that maximize the information gain. During hypothesis verification mode, the robot computes the distribution of discrepancy between human-updated hypothesis and incoming measurements, and suggests potential scientifically-valuable locations for further investigation.