Designing Intelligent Instruments

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Abstract

Remote science operations require automated systems that can both act and react with minimal human intervention. One such vision is that of an intelligent instrument that collects data in an automated fashion, and based on what it learns, decides which new measurements to take. This innovation implements experimental design and unites it with data analysis in such a way that it completes the cycle of learning. This cycle is the basis of the Scientific Method.

The three basic steps of this cycle are hypothesis generation, inquiry, and inference. Hypothesis generation is dealt with by artificially supplying the instrument with a parameterized set of possible hypotheses that might be used to describe the physical system. The act of inquiry is handled by an inquiry engine that relies on Loredo's Bayesian Adaptive Exploration [1] where the optimal experiment maximizes the expected information gain. Finally the act of inference is handled by Skilling's Nested Sampling algorithm [2], which allow us to test the various hypotheses given the newly collected data. With this data in hand, the instrument will refine its hypotheses, and repeat the cycle taking measurements until the system is described within a pre-specified tolerance.

We will demonstrate our first attempts toward achieving this goal with an intelligent instrument constructed using the Lego Mindstorms robotics platform.

References:

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