Bayesian Experimental Design with Variable Cost

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Abstract:

Mutual information (MI) is a commonly adopted utility function in Bayesian optimal experimental design (BOED). While theoretically appealing, MI evaluation poses a significant computational burden for most real world applications. As a result, many algorithms utilize MI bounds which are successively refined through additional computation, until a desired performance level is achieved. However, existing methods do not account for computational costs which vary by experiment design, leading to wasted cycles. Here, we consider the problem of adaptive allocation of computational resources in the course of BOED. Our proposed approach achieves the same minimum desired performance target as existing methods, but with fewer evaluations of the costly MI reward. Our approach adapts knapsack optimization of best arm identification problems, with several critical differences that impact overall algorithm design and performance. Firstly, observations of MI rewards are biased. Secondly, evaluating experiments incurs shared costs amongst all experiments (posterior sampling) in addition to per-experiment costs that may vary with increasing evaluation. We propose and demonstrate an algorithm that incorporates the variable cost into the refinement decision.