Engineering Risk Analysis Group
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MSc thesis

Black box optimization via Bayesian methods

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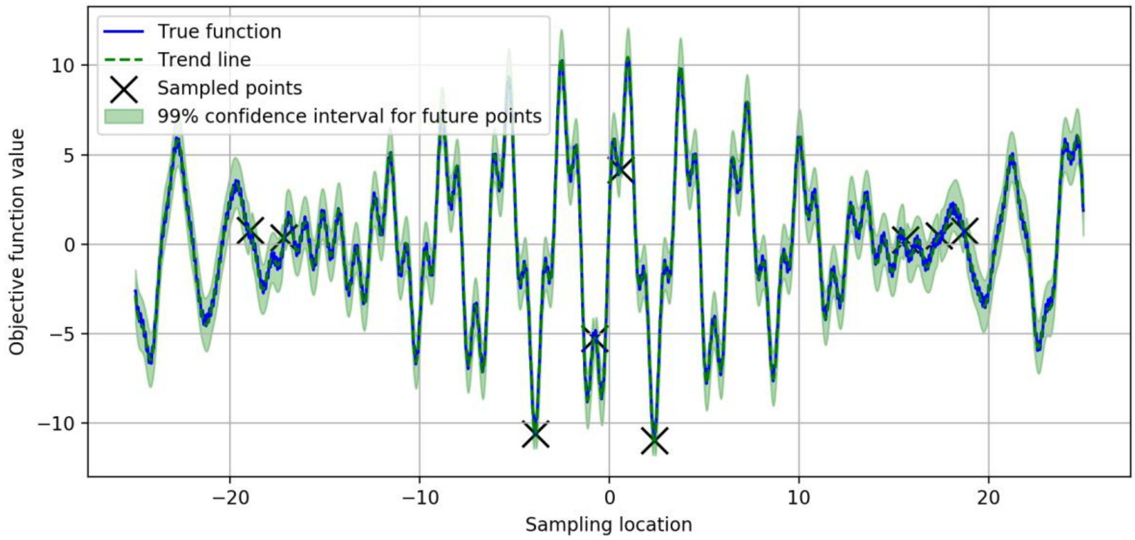
Background

One of the most common types of challenges in engineering are problems of global optimization. Often, these problems are further complicated by monetary cost or time required to sample the objective function. This makes the optimization algorithms commonly utilized for other types of optimization problems largely unusable, as they often require a significant number of samples to reach the optimum with any degree of precision. Response surface fitting methods offer an attractive alternative in this case, as they can significantly minimize the required number of samples by more effectively utilizing each individual sample. Efficient Global Optimization (EGO) proved to be one of the most efficient methods of this type. This thesis presents an optimization method based on Efficient Global Optimization, to achieve a better performance in cases where prior information regarding the functional form of the objective function is available.



Predictive distribution for future sampling points of a complex objective function that presents difficulties when optimized with commonly utilized methods after 9 previously sampled points. In this case, frequencies of the harmonic functions making up the objective function were assumed to be known in advance.

Methodology

Compared to the Efficient Global Optimization method, we model the assumed functional form of the response surface explicitly by utilizing prior information concerning the analytical components of the form. The Bayesian framework is utilized to model the uncertainty in the coefficients associated with the components. The selection of new sampling locations is done based on the expected information gain criterion. The Kullback-Leibler divergence between the parameter probability distributions before and after the sampling is utilized to measure the expected information gain.

Conclusion and Outlook

The proposed method has been described analytically and its performance was analyzed on a set of test functions. The method offers a significant performance improvement over the previously known optimization methods under the condition of known prior information about the noise and known functional basis of the true objective function. If the basis is unknown, or the noise parameters are selected improperly, performance of the method is not guaranteed. Further research could focus on alleviating the reliance of this method on prior knowledge about the noise and the functional basis of the objective function.

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