A kriging-based active learning algorithm for contour estimation of integrated response with noise factors

Abstract

Contours have been commonly employed to gain insights into the influence of inputs in designing engineering systems. Estimating a contour from computer experiments via sequentially updating kriging [also called Gaussian process (GP) models] has received increasing attention for obtaining an accurate prediction within a limited simulation budget. In many engineering systems, there are often two types of inputs: control factors specified by design engineers and uncontrollable noise factors due to manufacturing errors or environmental variations. To mitigate undesirable effects of noise factors, the integrated response, which is an expectation of the response with respect to noise factors, is a widely used robust performance measure. Predicting a contour of the integrated response is an important task to identify sets of control factors that maintain the integrated response at a desirable level. However, most of the existing literature focuses on estimating contours with only control factors and ignores inevitable noise factors. In this article, we propose an efficient active learning algorithm for estimating a contour of the integrated response from time-consuming computer models based on GP models. Two acquisition functions are proposed to determine the next design points of both control factors and noise factors for updating GP models to better estimate a contour. Closed-form expressions are developed to compute the AFs for facilitating optimization. Three numerical examples with different types of contours and a real aerodynamic airfoil example are used to demonstrate that more accurate contour estimates are obtained with the proposed active learning algorithm efficiently.

Keywords: Contour estimation, · Noise factor, · Integrated response, · Gaussian process model ,· Expected improvement, · Active learning