

Genetic Algorithm Optimization for Reduced Order Problem Based on Kriging Modeling with Restricted Maximum Likelihood Criterion

Guang Dong, CAE Engineer
CAE Group, Vehicle Engineering Department
Tesla Motors, Fremont, CA 94538
Tel: 650-681-6050
Email: gdong@teslamotors.com

John Cooper, Senior Manager
CAE Group, Vehicle Engineering Department
Tesla Motors, Fremont, CA 94538
Tel: 650-681-6050
Email: jcooper@teslamotors.com

Abstract

Complex and computationally intensive modeling and simulation of real-world engineering systems can include a large number of design variables in the optimization of such systems. Consequently, it is desirable to conduct variable screening to identify significant or active variables so that a simpler, more efficient, and accurate optimization process can be achieved. Genetic Algorithms (GA), as a popular optimization method, is an important member of the class of evolutionary algorithms (EA), which is inspired by the phenomenon of Darwin's concept of survival of the fittest. The algorithm generates solutions to the optimization problems by using the techniques inspired by the natural evolution, such as selection, crossover, and mutation. GA has been widely used to solve a variety of nonlinear optimization problems. This paper proposes a variable screening method based on Kriging modeling with Restricted Maximum Likelihood criterion to reduce the design space, and the GA is applied to optimize the re-defined problem with reduced order design space afterwards. The Kriging metamodeling method is more reliable for highly nonlinear systems, such as the complex engineering systems, than the traditional response surface method. Meanwhile, the Restricted Maximum Likelihood (REML) criterion makes the variable screening process more efficient. The REML method is not based on a maximum likelihood fit of all the information, but instead employs a likelihood function calculated from transformed data, and

it can produce unbiased estimates of variance and covariance parameters in contrast to the Maximum Likelihood Estimator (MLE). In addition, the MLE estimators are not involved in the optimization problem for the correlation parameter in the Kriging model, so it is not necessary to calculate these estimators. In this work, the Improved Distributed Hypercube sampling method is applied at the first sampling stage. After the design space is shrunk to a low dimensional space through the proposed nonlinear variable selection method, the GA method is then applied to find the optimal solution of the problem.

This strategy with the combination of variable screening method based on a Kriging modeling with Restricted Maximum Likelihood criterion and GA optimization method is evaluated using a standard benchmark nonlinear numerical example that employs 20 factors. The optimization strategy then is applied to an occupant restraint system design problem with 15 dimensional design space. After reducing the design space with the proposed variable screening method, the optimal restraint configuration is obtained by using GA. These two examples show that the optimization strategy proposed by this paper can solve the problem efficiently and effectively.

Keywords: Genetic Algorithm, Kriging Metamodeling, Restricted Maximum Likelihood Criterion.