



基于自适应重要抽样的可靠性分析方法

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Reliability analysis method based on adaptive importance sampling

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摘要

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摘要 基于自适应重要抽样(AIS, Adaptive Importance Sampling)的可靠性分析方法,能够克服基于蒙特卡洛方法分析小概率事件时存在的效率低、精度差问题.为解决显性失效方程不存在时寻找失效点困难问题,首先利用条件递归寻找失效点,并使之尽可能在失效面附近;以该失效点为采样中心,抽取失效样本,并不断调整采样中心,使失效样本不断靠近设计点;然后利用这组失效样本估计重要抽样函数的参数,再执行自适应迭代过程,直至失效概率的误差缩小到允许误差限内.最后通过两个典型案例对方法进行应用验证,仿真结果表明在没有失效方程的情况下,能够通过仿真方法很快找到失效点,表明对于不存在显性失效方程的系统,该方法同样适用.与蒙特卡洛方法的对比结果表明该方法在仿真效率上具有较大优越性,且失效概率越小,这种优越性越明显.

关键词: 可靠性 蒙特卡洛方法 仿真 自适应重要抽样方法 递归

Abstract: Low efficiency and accuracy problem is serious when analyzing the rare event using Monte Carlo methods, a reliability analysis method was proposed based on the adaptive importance sampling (AIS). Finding the failure points is difficult when the failure equation is not explicit. Firstly a conditioned recursion algorithm was used to search the failure point which was as close as possible to failure surface. Then the failure point was selected as the new sample center, and the center point was adjusted iteratively to get a failure sample nearby the design point. The failure sample was used to predict the parameters of importance sampling density function; iteration will be performed during the process until the deviation of failure probability met the requirement. Finally, two typical cases were used to verify the method; simulation results show that the failure point can be searched quickly through simulation method without an explicit failure equation, which means it is applicable to the situation where failure equation is implicit. Comparison results with Monte Carlo methods prove that simulation efficiency is increased obviously, especially for the application condition with very small failure probability.

Keywords: reliability Monte Carlo methods simulation adaptive importance sampling methods recursion

Received 2010-04-27;

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引用本文:

马纪明, 詹晓燕, 曾声奎.基于自适应重要抽样的可靠性分析方法[J] 北京航空航天大学学报, 2011,V37(9): 1142-1146,1150

Ma Jiming, Zhan Xiaoyan, Zeng Shengkui.Reliability analysis method based on adaptive importance sampling[J] JOURNAL OF BEIJING UNIVERSITY OF AERONAUTICS AND A, 2011,V37(9): 1142-1146,1150

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