Global sensitivity analysis improvement of rotor-bearing system based on the Genetic Based Latine Hypercube Sampling (GBLHS) method

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Abstract. ~~—~~Sobol method is applied as a powerful variance decomposition technique in the field of global sensitivity analysis (GSA). In the present study, convergence speed of the extracted Sobol indices ~~is~~ was improved by a new proposed technique ~~which is~~ called genetic based Latine hypercube sampling (GBLHS). This technique is an improved version of restricted Latine hypercube sampling (LHS) and the optimization algorithm ~~is~~ was inspired from genetic algorithm, but in a different ~~strategies~~ strategy in crossover and mutation operators. The improved Sobol method ~~is~~ was used to perform factor prioritization and fix~~ing of~~ an uncertain comprehensive high speed rotor-bearing system. The finite element method ~~is~~ was employed for rotor-bearing modeling by considering Eshleman-Eubanks assumption and interaction of axial force on the rotor whirling behavior. The results of the GBLHS technique ~~are~~ were compared with the Monte Carlo Simulation (MCS), LHS and Optimized LHS (Minimax. criteria). Convergence speed of the sensitivity indices and as a result the computation time of the sensitivity analysis using GBLHS ~~have been~~were improved significantly.

Keywords. Global sensitivity analysis, Sobol method, genetic based Latine hypercube sampling, rotor-bearing system, uncertainty analysis

1. Introduction

One of the main issues for scientists and engineers is to minimize uncertainty, which is the behavior discrepancy between the model and real operation of the system. This minimization leads to increased reliability (Jafari *et al.* 2015, Y. Liu *et al.* 2016, Muscolino *et al.* 2016) and fatigue life (Paolino *et al.* 2013), improved fault detection (Petryna *et al.* 2005), as well as diagnosis and prognosis (Mirzaee *et al.* 2015, Gobbato *et al.* 2012, Wei e*t al.* 2015) of systems and robust optimization (Guo *et al.* 2015, Zhao *et al.* 2014). The causes of the discrepancy are due to the aleatory uncertainty (e.g. parameter uncertainty, temporal and spatial variability known as natural variability) and epistemic uncertainty (e.g. model reduction or simplification known as modeling error). Because of inevitability of these causes, an uncertainty analysis is crucial in the designing process of delicate systems.

Many ~~researches~~ studies have been conducted in the field of uncertainty analysis by statisticians and engineers (Paté-Cornell 1996, Faber 2005). From them, several studies have been conducted in the area of stochastic analysis of vibrating structures, which are summarized in ~~table~~ Table 1. Uncertainty analysis methods used in previous studies can be classified into two main categories: statistical techniques (e.g. crude Monte Carlo simulation in non-intrusive way and other sampling based methods) and non-statistical techniques (e.g. Neumann expansion method (Benaroya *et al*. 1988) and other stochastic finite element methods (Minh *et al.* 2016)).

In the field of uncertainty analysis, from the real-life application standpoint, ~~It~~ it is remarkable to determine ~~that, from the real life application standpoint,~~ which uncertainty sources are the most influential (factor prioritization strategy) and which of them are the least or non-influential (factor fixing strategy). The study of uncertainty influence (variation of input factors) ~~in~~ on the output of a model can be accomplished by sensitivity analysis.

Table 1. Some outstanding studies in the field of Uncertainty Analysis (UA) of structural dynamic system

Contributor	Case Study and (uncertainty sources)	Methodology