



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

This thesis aims to develop high-fidelity polynomial dimension decomposition schemes for stochastic computation. It is achieved in multiple stages using efficient modelling of bases, decomposition terms, unknown coefficients and error terms. Using these improvements, this study proposes the following novel schemes – (a) Two-Step Adaptive Response Surface Method (RSM), (b) Sequential Stochastic Response Surface Method (Seq. SRSM), (c) Adaptive Multiple Finite Difference High Dimensional Model Representation (AMFD-HDMR), (d) Dimension AMFD-HDMR (*d*AMFD-HDMR) and (e) Hybrid Dimension AMFD-HDMR (*hd*A-HDMR). Also, a new sequential support point generation scheme is also proposed in this thesis for efficient construction of the meta-model. For this purpose, Clenshaw-Curtis sparse grid is adopted to generate the support point using selective tensor product based on the hierarchy as per Smolyak's algorithm. This scheme employs three key features – multi-level sequential generation, distribution and dimension adaptiveness. Both, dimension decomposition and support points generation are developed for different non-intrusive applications to address the curse of dimensionality.

The two-step adaptive RSM is proposed for efficient reliability based design optimization (RBDO). Two sets of separate response surfaces using moving least square (MLS) technique are constructed to determine the optimal design point and the response statistics necessary for the constrained optimization. The MLS based adaptive determination of unknown coefficients is extended further using polynomial chaos expansion (PCE) to develop the stochastic response surface (i.e. Seq. SRSM) for better accuracy. Further, the accuracy is improved by representing it in terms of orthogonal subfunctions under AMFD-HDMR. This proposal uses finite difference HDMR to provide an iterative multi-order multi-level dimension decomposition technique for reliability analysis. The issue of curse of dimensionality is further addressed by a novel approach using *d*AMFD-HDMR. It decomposes the original performance function into summands of smaller dimensions using a sparse formulation of HDMR based on sensitivity analysis. Use of MLS technique yields a scalar approach where matrices are inverted for each realization. This affects the tractability of meta-modelling due to computational time required in training and approximating multiple realizations of MCS. To address this demerit, a hybrid scheme (i.e. *hd*A-HDMR) is suggested where the coefficients are determined using a Gaussian process. The global error of the multiple HDMRs is decomposed into the error terms of each subfunction. Overall, each proposal is validated using various problems to demonstrate their performance which clearly establishes that the proposed algorithms can be adopted for large class of practical reliability based design problems.