論 文 の 内 容 の 要 旨

論 文 題 目　　Multi-Fidelity Uncertainty Quantification and Surrogate-Based Memetic Algorithm for Design Under Uncertainty
（不確実性下での設計に対するMulti-Fidelity不確定性定量化とSurrogate-Based Memeticアルゴリズム）

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This dissertation deals with the development and improvement of metaheuristic optimizer and uncertainty quantification (UQ) algorithm to tackle expensive engineering robust optimization problem. Due to the limited availability of computational budget, this tight budget has to be optimized to put it on the best use. This could be done via two ways: increasing the efficiency of the optimizer and improving the effectiveness of the UQ algorithms. An improvement of local surrogate-assisted multiobjective memetic algorithm (SS-MOMA) was investigated and studied in this work to improve the optimization algorithm's effectiveness to locates and exploits the Pareto front. The improvement on the optimizer side was mainly done by investigating the capability of various local search method to find the optimum of the subproblem. On the UQ side, a flexible and robust UQ method based on multi-fidelity non-intrusive polynomial chaos with regression was developed in this thesis. The method takes the advantage of flexible sampling and polynomial basis to estimate the polynomial coefficients as an alternative to the previously existing method that uses spectral projection. The improved optimizer shows that the local search based on achievement scalarizing and Chebyshev function were able to find higher quality solutions than the previous SS-MOMA that uses weighted-sum method for the local search. A dynamic normalization method based on the value of the offspring population was also introduced where the results on test problems clearly shows the improved diversity of the solutions. Moreover, on the UQ side, the new multi-fidelity algorithm successfully improved the approximation quality of the stochastic response surface with the requirement that the low-fidelity function should has high correlation and relatively low error to the high-fidelity function. It was tested on several aerodynamic problems

and shows evident improvement when the partially converged simulation was used as the low-fidelity samples. Both the optimizer and UQ were then applied to transonic airfoil robust optimization problem with the performance and robustness of lift-to-drag ratio as the objectives. Results on airfoil robust optimization revealed that the performance and robustness of lift-to-drag ratio are two conflicting objectives. However, closer examination revealed that only the airfoil with maximum mean is optimal in the true sense; although it is accompanied with high standard deviation. This is because the performance of the maximum mean airfoil is better than the other extremum airfoil over the response surface.