Uncertainty propagation in multi-agent system for multidisciplinary optimization problem

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Because of uncertainties on models and variables, deterministic multidisciplinary optimization may achieve under-sizing (without design margins) or over-sizing (with arbitrary design margins) Therefore it is necessary to implement multidisciplinary optimization methods that take into account the uncertainties in order to design systems that desired levels of reliability and robustness. Probabilistic methods such as reliability-based design optimization (RBDO) and robust design methods, provide designers with powerful decision-making tools but may involve very time-consuming calculations. It is due to the double loop involved in the optimization: one iteration of the optimization process followed by a probabilistic analysis. Indeed, in order to determine the probabilistic characteristics of the system performances at a design point, we need to perform costly computations, for example by using a Monte Carlo approach, importance sampling,), or other approximation methods (such as FORM, SORM, etc.). Many researches have been conducted to develop techniques to overcome the double loop procedure, such as RIA (Reliability Index Approach) or PMA (Performance Measure Approach) methods.

Beside these developments, new optimization approaches have also been developed to deal with large industrial problems. Indeed today's systems are increasingly complex and design methods deployed involve multilevel and multidisciplinary aspects. Even in the absence of uncertainty the classical optimization techniques can be difficult to implement in order to address these complex problems, for which the number of variables, models and interdependencies is high. Thus, solving such complex optimization problems requires the development of new efficient methods. Auto-adaptive Multi-Agent Systems (AMAS) is a new approach developed recently, allowing to take into account the various aspects previously mentioned: multi-level, multidisciplinary and computation burden. This approach was in particular suggested for solving complex deterministic optimization problem. Nevertheless, the question of the integration of uncertainties in this multi-agent based optimization arises. The aim of this paper is to propose an approach for integrating the treatment of uncertainties in auto-adaptive multi-agent system solving. The developed method employs a single loop process in which cycles of deterministic optimization alternate with evaluations of the system reliability. For each cycle, the optimization and the reliability analysis are decoupled from each other. The reliability analysis is carried out at agent level and only after the resolution of the deterministic optimization, to verify the feasibility of the constraints under uncertainties. Following the probabilistic study, the constraints violated (with low reliability) are shifted to the area of feasibility by integrating safety coefficients whose calculations are based on the agent-level reliability information. The method developed is both applied to an analytical test case inspired from academic example (Alexandrov problem), and to a conceptual aircraft design problem.