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# Combining Multiparametric Strategy and Gradient-Based Surrogate Model for Optimizing Structure Assemblies

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## 1. Abstract

Optimization strategies on assembly design are often relatively time expensive because of the large number of non-linear calculations (due to contact or friction problems) required to localize the optimum of an objective function. In order to achieve this kind of optimization problems with an acceptable computational time, we propose to use a two-level model optimization strategy [1]. The whole optimization process can be described as follows: in the first level, a metamodel, a dedicated strategy for solving assembly problems and a global optimizer are used to obtain an approximated optimum. In the second level, mechanical model is connected directly with a local optimizer for locating the precise optimum.

Solving assembly problem is the main lock of this approach. For the purpose of solving problems with friction or gap between parts, we propose to employ a finite element method based on a mixed domain decomposition and on an iterative scheme called the LaTIn method [2]. This algorithm allows us to obtain an approximated solution over the whole loading path and at all points of the structure. On each iteration the approximated solution is enriched. In the context of parametric optimization solved problems are very similar in the sense that only the parameters vary. For a new set of design parameters, the LaTIn algorithm can be reinitialized using a previous converged solution and enables us to obtain faster convergence. Thus a significant reduction of computational time is obtained. The reuse of converged solution is denoted as MultiParametric Strategy [3].

Thanks to the MultiParametric Strategy the gradients of the objective function can be computed very inexpensively. Therefore we propose to use this information to build some richer kind of metamodels. One of them is called *Cokriging* or *gradient-based Gaussian Process* [4].

The prediction of the response of a function on any point of the space is made from the real deterministic evaluations and gradients of the quantity of interest.

Kriging-based metamodel requires the estimation of a covariance structure to be built and provides an error of approximation in addition to the approximated response. This information allows us to achieve an iterative improvement of the metamodel using a classical infill criteria such as Expected Improvement [5]. Finally a global optimization based on a particle swarm optimizer enables us to obtain an approximated optimum and the associated set of parameters.

The second level provides a precise optimum using the MultiParametric Strategy and a local optimizer. The whole strategy allows us to reduce significantly the computation time associated to the resolutions of the assembly problem and, consequently, of the whole optimization process. This strategy will be presented on two- and three-dimensional academic and actual test cases with many numbers of design parameters.

**2. Keywords:** multilevel optimization, metamodel, multiparametric, LATIN method, assemblies.

## 2. Acknowledgement

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## 3. References

**[1]** G.M. Robinson and A.J. Keane, A case for multi-level optimisation in aeronautical design, *Aeronautical Journal*, 103(1028):481–485, 1999.

**[2]** P. Ladevèze, *Nonlinear computational structural mechanics: new approaches and non-incremental methods of calculation*, Springer Verlag, 1999.

**[3]** Pierre-Alain Boucard, Application of the latin method to the calculation of response surfaces, In *Proceeding of* *the First MIT Conference on Computational Fluid and Solid Mechanics, Cambridge, USA*, volume 1, pages 78–81, Juin 2001.

**[4]** Luc Laurent, Pierre-Alain Boucard, and Bruno Soulier, Generation of a cokriging metamodel using a multi-parametric strategy, *Computational Mechanics*, 51(2):151–169, February 2013, 10.1007/s00466-012-0711-0.

**[5]** D.R. Jones, M. Schonlau, and W.J. Welch, Efficient global optimization of expensive black-box functions, *Journal of Global optimization*, 13(4):455–492, 1998.