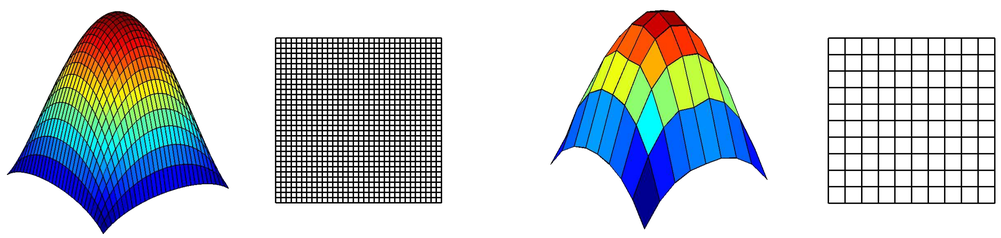
Two-Level Optimization

David Echeverria Ciaurri, CWI, Amsterdam • Charles Tong, LLNL, Livermore

A large number of optimization procedures are based on highly accurate models that typically have an excessive computational cost. By exploiting auxiliary models that are less accurate but much cheaper to compute, a significant speed-up can be obtained for those expensive procedures.

Introduction

During optimization we iteratively evaluate models that describe physical phenomena. Fine (accurate) models are often expensive but yield precise results. Coarse (fast) models can be employed to obtain in general only an approximation of the fine optimum.

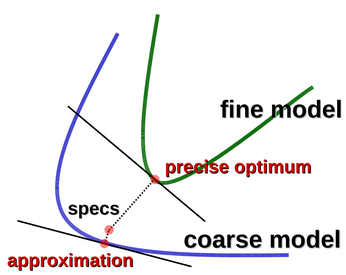


Fine model (e.g. fine grid) Coarse model (e.g. coarse grid)

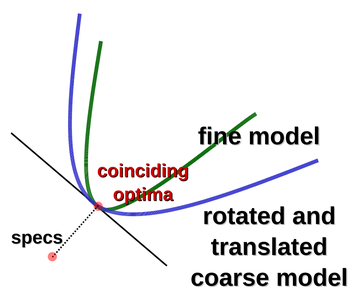
But can we speed-up the very time-consuming optimization of the fine models with the aid of the coarse ones?

Manifold Mapping Optimization

We combine both types of models to efficiently compute the precise optimum. The coarse model is iteratively aligned with the fine one.



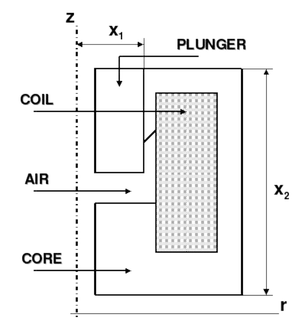
Original misalignment



Coarse model mapping

Example: Actuator Design

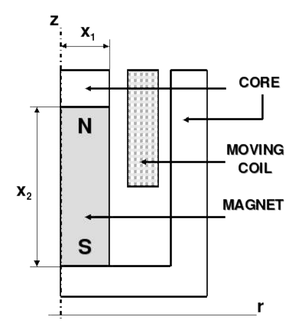
A. Automotive magnetic actuators provide high levels of force.



	PM	RQP	SQP	MM
# fine model evals.	9	7	7	1
cost function	48.8	48.8	48.5	48.5

PM: Penalty Method, RQP: Recursive Quadratic Programming, SQP: Sequential Quadratic Programming, MM: Manifold Mapping

B. Linear voice coil actuators give torque-free force outputs.



	NMS	SQP	MM_1	MM_2
# fine model evals.	24	31	9	4
cost function	4.6	4.6	4.6	4.6

NMS: Nelder-Mead Simplex, SQP: Sequential Quadratic Programming, MM: Manifold Mapping with different coarse models 1 and 2

In both cases the cost function is minimized with manifold mapping (MM) and some other optimization schemes. The first row in each table is approximately proportional to the total computing time.

Conclusions and Future Work

Two-level optimization can be used to speed-up design processes based on very time consuming physical models.

Multi-level optimization is now subject of further research.

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