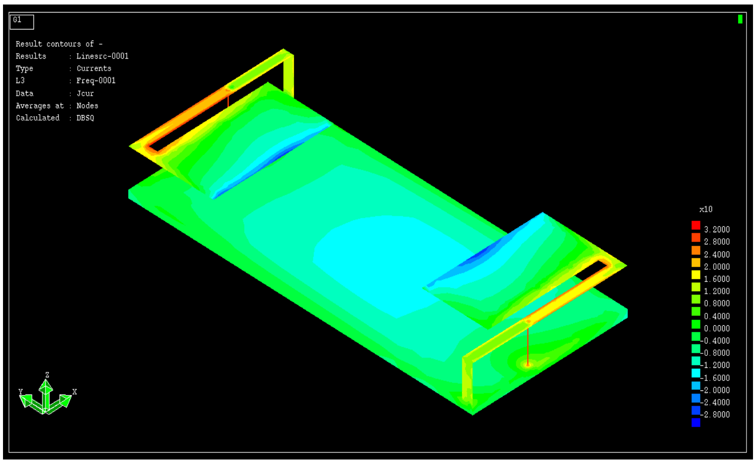
Fraunhofer CHALMERS
Research Centre
Industrial Mathematics

Multi-objective Optimization of a MIMO Antenna System Using efield®

The performance of an antenna system depends on many different aspects. There are requirements on for example scattering parameters, signal correlation, bandwidth and antenna size. These requirements are often in conflict and the traditional way of dealing with this problem is to weight these requirements into a single objective and perform an optimization. The trial-and-error approach of setting those weights has many disadvantages, the weights are often highly sensitive and no trade-off discussion is possible. A more attractive alternative is to avoid weights and instead optimize the objective functions simultaneously subject to certain constraints. In multi-objective optimization the goal is to obtain an accurate approximation of the Pareto front. A solution belongs to the Pareto front if an improvement in one objective leads to a deterioration in at least one of the other objectives.

Unfortunately, to perform multi-objective optimization based on black-box simulations of a complex design problem is computationally expensive and generic approaches therefore often fail. Tailor-made solutions are required and based on a new approach the Fraunhofer institutes ITWM and FCC have successfully demonstrated in several application fields that multi-objective optimization is both feasible and extremely powerful.



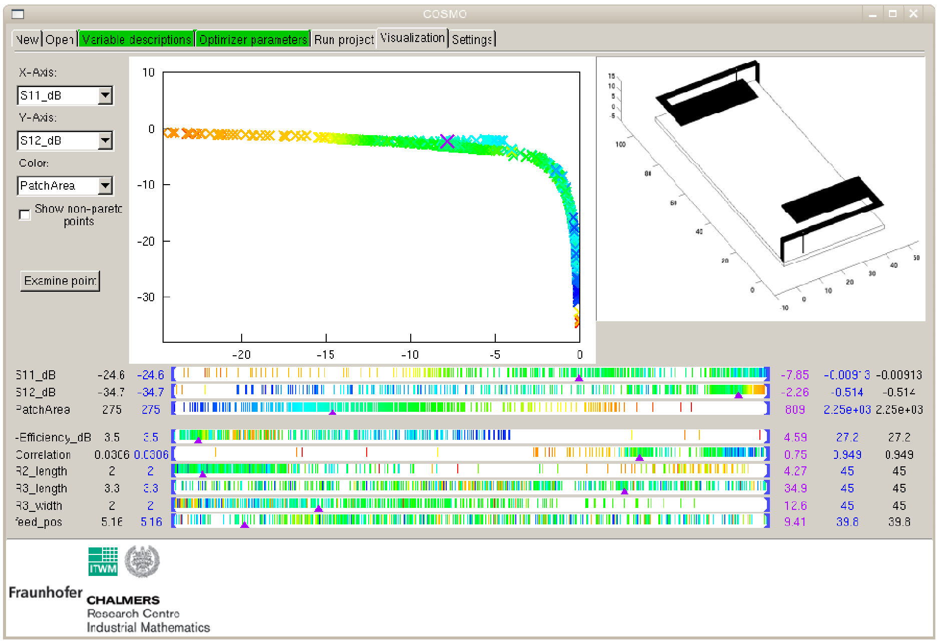
Visualization in efield® of the surface currents at 775 MHz on the MIMO system for the design with best efficiency.

The whole Pareto front is a too large class and it includes many bad compromises. Our strategy is to compute a database of systematically chosen, pre-computed, Pareto-optimal solutions as follows:

1) Find a good preset solution that balance the objectives
2) Define the domain and adapt to box constraints to focus on relevant parts
3) Explore the domain by extreme compromises
4) Fill the domain by building a coarse grid of representatives

With a tight coupling between simulation and optimization the concept of optimization driven discretization can be utilized to drastically reduce the computational cost for calculating a coarse approximation of the database. Interpolation is then used on convex patches to realize a continuous real time navigation in the database. Together with tools for navigation in the database the antenna designer makes the decision of optimal solution when all possibilities and limitations are known.

In a project together with the Antenna Research Centre at Ericsson, we developed a prototype of a decision support system for optimization of MIMO (multiple input multiple output) antenna systems. The prototype offers visualization in a database of discrete Pareto optimal antenna designs. Novel RBF-based algorithms designed for accurate approximation of objectives with sharp gradients have been used in combination with the efield® electromagnetic solvers and CAD routines.



Snapshot of a decision support system for antenna optimization. In this case there are three objectives and four design parameters. The antenna efficiency and correlation are also calculated. During the navigation the designer makes restrictions and selections until a final design candidate has been chosen.

With a team of around 25 researchers in optimization at our sites in Kaiserslautern and Göteborg we offer

- Development and implementation of optimization algorithms for best possible solutions
- Integration of simulation and optimization software
- Development and implementation of decision support systems that integrate multiple criteria optimization and simulation

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