Fixed and sequential designs for optimisation of fan shapes

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The Institute of Mathematics of Toulouse is cooperating (among other university laboratories) with the Valeo firm on optimisation of car engine fan shapes. The study uses a complicated code to assess the performance of some geometries of fans as, for example, the max camber height, the stagger angle the chord length etc.. The optimization demands the construction of a meta-model easy to use.

In a first step a method for constructing space-filling designs of size 300-600 in a parametric space of dimension 15-30 have been investigated. A non limitative list is given by: optimized LHS; low discrepancy sequences ; orthogonal arrays and a new method based on determinantal processes. This last method is a way of constructing repulsive point process that avoid concentration zones due to randomness. Basically the correlation function of the process is defined by a determinantal function associated to some kernel [2, 3].
The comparison was conducted using classical criteria as: mindist; MST; L^2 discrepancies. We worked in very large dimension situations : 300 points in a space of dimension 15-30 is almost nothing! Results shown no clear-cut result and in particular the basic optimized LHS gave a fair trade-off between the considered criteria.
In a second step, we chose to explore sequential designs. Although we do not have any relevant model to optimize with, we know that the efficiency of the

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fan is a very relevant parameter and that geometries with low efficiencies are definitely not interesting.
On the other hand our goal is not a simple search of a unique geometry optimizing the efficiency since the firm has to follow different specifications depending on the type of car considered.
So we decided to adopt a functional point of view considering the flow of the fan as a parameter. The maximal efficiency as a function of the flow is detected using a quadratic model and this maximal efficiency is used as a response.
On this response ans using a Kriging meta-model based on Gaussian process with Matern covariance, we used the Expected Improvement method [1,4] to add new points to a preliminary optimized LHS.
In a future work this will be compared with UCB method that chose as next point the maximum of the upper limit of confidence region.

References

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