Separating Product Design Optimization

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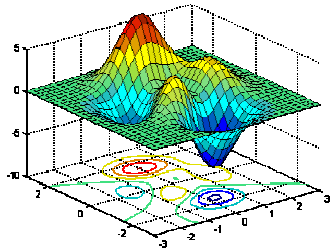
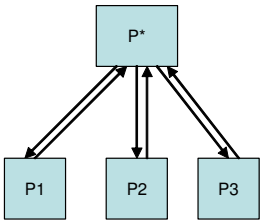
Optimization

Designers use optimization techniques to determine values for design variables to optimize an objective function while satisfying performance requirements and other constraints.



Decomposition

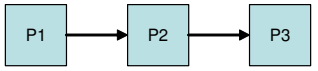
The difficulty of solving large scale optimization problems has motivated various decomposition approaches, but many of these methods require multiple iterations to converge to a feasible, optimal solution, which leads to extensive effort in some cases.



A typical decomposition scheme uses a second-level problem to coordinate the subproblems.

Separation

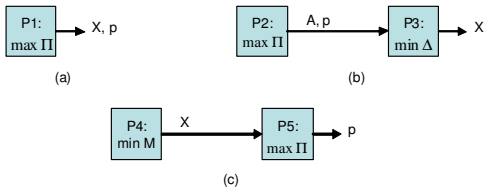
Our approach, which we call ***separation***, replaces a large design optimization problem with a set of subproblems, solves each subproblem once, and produces a feasible solution without iterative cycles. An exact separation finds an optimal solution to the original problem. Approximate separations find near-optimal solutions.



Separation yields a set of subproblems. Solving one subproblem provides the input to the next.

Profit Maximization without Competition

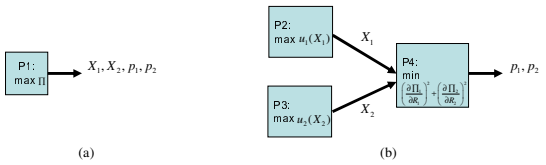
We considered different separations of the profit maximization problem for an universal electric motor and compared to the solution found from an all-at-once formulation. We found that maximizing customer satisfaction leads to better solutions that optimizing mass or efficiency.



(a) The all-at-once formulations (A1) and (A2) maximize profit. (b) Separation S1 finds the most profitable attribute values and price and then sets the design variables to satisfy them. (c) Separation S2 finds the best design and then sets the price to maximize profit.

Profit Maximization under Competition

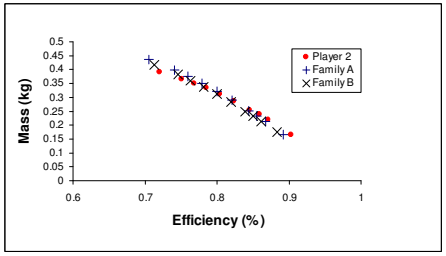
We modeled the problem of designing an universal electric motor as a mixed motive game in which each manufacturer makes independent product design and pricing decisions. We found an exact separation with three subproblems that yield the optimal product design and price.



(a) The all-at-once formulations to maximize profit. (b) Separation P1 and P2 finds the best utility values and design variables for both player and then sets price for the best design.

Product Family Design under Competition

We modeled the problem of designing a family of universal electric motors (with ten different torques) as a zero sum game. We compared different separations and found that a separation that maximized total utility yielded a near-optimal product family.



(a)

(a) The Mass and Efficiency of Each Player's Products.