Solution of multiobjective optimization problems via non-hierarchical analytical target cascading: A quasi-separable MDO formulation

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Multidisciplinary design optimization (MDO) methods aim at addressing the presence of several, and often strongly, coupled analyses in numerical optimization of engineering systems. Typically, this is accomplished by a decomposition and coordination strategy, which can be object- or discipline-oriented. Multiobjective optimization (MO) aims at quantifying the tradeoffs among competing objectives in a design optimization problem; this is accomplished by generating a number of mathematically equivalent solutions (the Pareto set of solutions). This procedure can be costly, especially for problems with even a moderate amount of objectives, as it requires the solution of the problem for each Pareto point. Therefore, it is common to reduce the number of objectives as much as possible by treating most, if not all but one, objectives as constraints. Pareto points can be generated, if desired, by parametric studies on the constraint bounds, since active constraints indicate competing objectives.

In this paper, we consider quasi-separable problems, which have been studied in the literature as MDO problems. We make the observation that the formulation of quasi-separable MDO problems is equivalent to a multiobjective optimization problem whose objectives have been aggregated into a single objective function using the weighted sum method with equal weights. We can thus apply the non-hierarchical analytical target cascading (ATC) methodology, applicable to MDO problems, to obtain single-pojnt solutions of multiobjective problems. Besides the theoretical interest of this observation, possible practical value of this approach is potential efficiencies gained in producing targeted Pareto points using quasi-separable problem solution strategies.

Our research is motivated by a suspension design application for commercial vans. Ride and handling (R&H) performance considers multiple objectives such as ride comfort, controllability, and stability. We use a nonhierarchical ATC decomposition to formulate the multiobjective problem as a quasi-separable MDO problem. At the vehicle level, optimal kinematic and compliance (K&C) characteristics are obtained to satisfy R&H performance targets for each objective. K&C characteristics are represented by polynomial curves, whose coefficients are cascaded to the system level as targets. CarSim is used for the simulation model of vehicle performance. At the system level, the optimal hard points and bush stiffness of suspensions are calculated to satisfy the K&C characteristics targets of the vehicle level. Motionsolve is used for the analysis model of suspension level.