Multiobjective Complex Systems:
Decomposition, Coordination, and Applications in Engineering Design

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Abstract

A *complex system* is defined to be a natural or engineered system that is difficult to understand and analyze because (1) it has multiple and dissimilar components or subsystems that may be connected in a variety of ways, and (2) is characterized by noncomparable and conflicting criteria or objectives such as cost, performance, reliability, safety, productivity, affordability, and others. In the presence of interacting components and multiple criteria, a unique decision optimal for the system does not exist but rather many or even infinitely many decisions are suitable.

Complex systems are modeled as collections of multiobjective optimization problems (MOPs) each representing a subsystem (or component) of the overall system. Since the calculation of efficient sets of such systems is challenging if not impossible, the following two-step strategy is proposed: (i) decomposition of the overall system into component MOPs, and (ii) coordination of the efficient sets of the components MOPs to construct the efficient set of the complex system without ever dealing with this system in its entirety.

Decompositions are briefly presented for a variety of complex systems. For two types of complex systems resulting from specific applications in engineering design, decomposition and coordination are developed in more detail. One case leads to advances in multiobjective optimization while the other extends the theory of single objective optimization for iterative augmented Lagrangian coordination techniques and the block coordinate descent method.