

EVOLUTIONARY BILEVEL OPTIMIZATION

Kalyanmoy Deb and Ankur Sinha

Many practical optimization problems should better be posed as bilevel optimization problems in which there are two levels of optimization tasks. A solution at the upper level is feasible if the corresponding lower level variable vector is optimal for the lower level optimization problem. Consider, for example, an inverted pendulum problem for which the motion of the platform relates to the upper level optimization problem of performing the balancing task in a time-optimal manner. For a given motion of the platform, whether the pendulum can be balanced at all becomes a lower level optimization problem of maximizing stability margin. Such nested optimization problems are commonly found in transportation, engineering design, game playing and business models. They are also known as Stackelberg games in the operations research community. These problems are too complex to be solved using classical optimization methods simply due to the "nestedness" of one optimization task into another. Evolutionary Algorithms (EAs) provide some amenable ways to solve such problems due to their flexibility and ability to handle constrained search spaces efficiently. Clearly, EAs have an edge in solving such difficult yet practically important problems. In the recent past, there has been a surge in research activities towards solving bilevel optimization problems. In this tutorial, we will introduce principles of bilevel optimization for single and multiple objectives, and discuss the difficulties in solving such problems in general. With a brief survey of the existing literature, we will present a few viable evolutionary algorithms for both single and multi-objective EAs for bilevel optimization. Our recent studies on bilevel test problems and some application studies will be discussed. Finally, a number of immediate and future research ideas on bilevel optimization will also be highlighted.