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Robust Reconfiguration Planning of Mixed-model Assembly Lines Under Uncertainty

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Abstract

Assembly lines often operate for many years, but they require frequent reconfigurations as new product models replace older ones. These changes can be costly, particularly if the line lacks sufficient flexibility. This study investigates the design of a mixed-model assembly line while specifically considering different future evolutions of the product family throughout its lifecycle. Moreover, the evolution of technology makes the availability of resources (robots and equipment pieces, etc.) uncertain for the future design of the line to be able to re-act to the future product evolution. We study a mixed-model line with multiple sequential stations. Each station has a single resource, either a worker or a robot, along with the necessary equipment pieces to complete its tasks. When a new product model replaces an older one, the assembly line needs to be reconfigured. Over time at each reconfiguration period in the stations, by the development of technology, new resources may become available and replace older ones. These new technologies allow the assembly line to produce different product models within the same product family. Also, during reconfiguration, resources and equipment can be moved between stations, and tasks can be reassigned to different stations. To address this problem, we adjust a Mixed-Integer Linear Programming (MILP) which has been developed in our latest paper considering uncertainty on product evolution through a scenario tree. In the present work, we propose to extend the model to other sources of uncertainty, i.e., product demands, processing times, and resource availability using corresponding robust optimization techniques. We first define uncertain models for the different uncertain parameters and then apply a worst-case robust optimization approach on uncertain constraints to define robust long-term strategies for reconfiguration planning under different budget uncertainty sets. Several computational tests on benchmark data validate our models and show the performance of our robust models considering the different uncertainties mentioned. Moreover, we compared these uncertainties to each other to see how they impact the reconfiguration planning of such lines. Results will be discussed within the presentation.

Keywords
Robust optimization, Mixed model assembly line, Reconfigurability, Worst-case analysis, Budget uncertainty.