A Dynamic Programming Algorithm with Dynamic Upper Bound for the Robotic Assembly Line Balancing Problem

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ABSTRACT

We consider the robotic assembly line balancing problem (RALBP), the problem of assigning tasks, parts and tools on a robotic assembly line to robot cells in such a way that the number of robot cells is minimum for given cycle time, tray capacity and slot capacity. In the simple assembly line balancing problem (SALBP), only tasks were concerned for being assigned to minimum number of work stations under the precedence restrictions and cycle time restrictions. But in RALBP, when a task is assigned to a robot cell the part and tool required to perform the task should be assigned together. And, in addition to the restrictions under SALBP, storaging space for parts and the number of slots for tools at each robot cell should not exceed tray capacity and slot capacity respectively. Moreover, some parts and tools may be shared by different tasks.

We give a dynamic programming algorithm which uses the concept of dynamic upper bound from Easton (1990) for solving RALBP. The recursion proceeds stage by stage growing the feasible sequence tree until it reaches the final stage, stage N where N is the number of tasks to be performed on the line. We facilitate the algorithm with three fathoming rules to be used for pruning unneeded partial solutions. Dynamic programs facilitated with fathoming tests, however, often fail to effectively prune the unneeded partial solutions when the tests are based on a nonoptimal incumbent solution, because relatively few partial solutions are eliminated. To overcome such a shortcoming, we need to find an improved upper bound dynamically. So our algorithm seeks a new incumbent solution whenever a signal is perceived during the ordinary recursion suggesting an improved upper bound is likely to exist. The fathoming rate at which partial solutions are fathomed provides a running indication of the quality of the current incumbent solution. Some other indicators serving as signal are also given. We compare the performance of our algorithm with a cutting plane algorithm for RALBP developed earlier by us. Computational results are provided.