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Chapter XIV

Artificial Neural Networks in Manufacturing: Scheduling

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Abstract

In this chapter, a neuroadaptive scheduling methodology, approaching machine scheduling as a control-regulation problem, is presented and evaluated by comparing its performance with conventional schedulers. Initially, after a brief reference to the context of existing solutions, the evaluated controller is thoroughly described. Namely, the employed dynamic neural network model, the subsequently derived continuous time neural network controller and the control input discretization that yield the actual dispatching times are presented. Next, the algorithm guaranteeing system stability and controller-signal boundedness and robustness are evaluated on an existing industrial test case that constitutes a highly nonacyclic deterministic job shop with extremely heterogeneous part-processing times. The major simulation study, employing the idealistic deterministic job-shop abstraction, provides extensive *comparison with conventional schedulers, over a broad range of raw-material arrival rates, and through the extraction of several performance indices verifies its superb performance in terms of manufacturing-system stability and low makespan, low average lead times, WIP, inventory, and backlogging costs. Eventually, these extensive experiments highlight the practical value and the potential of the mathematical properties of the proposed neuroadaptive controller algorithm and its suitability for the control of nontrivial manufacturing cells.*

Introduction

Production scheduling deals with the allocation of the available resources over time for the manufacture of goods. It involves the decision-making mechanism whose objective is finding a way to assign and use the sequence of shared resources (labor, material, equipment), such that production constraints are satisfied and production costs are minimized.

In this chapter we address a machine-scheduling problem that, while constituting a simplified formalism of the production scheduling, still captures its fundamental complexity. More precisely, we focus on the deterministic job-shop scheduling, whereas a set of n jobs is processed on a finite set of m machines, with precedence constraints imposed on the sequence of individual operations.

The examined scheduling problem, deterministic job-shop scheduling, is the most general classical scheduling problem and due to its factorial explosion is classified into the large class of intractable numerical problems (NP) known as NP-hard, that is, problems that cannot be solved in time polynomial to the dimension of the problem under consideration. Job-shop scheduling due to its importance to the efficient management of manufacturing processes has been addressed by a plethora of approaches.

Next, a reference to industrial practice and to the existing approaches to job-shop scheduling is made, and the essence of our proposed scheduler along with the intended evaluation methodology is outlined.

Background

Current industrial practice has been mainly based on assisting experienced human schedulers with major software packages that implement distinct scheduling philosophies like manufacturing resource planning (MRP), just-in-time (JIT) production (Schonberger, 1983), and optimized production timetables (OPT), while more recently enterprise-resource planning systems (ERPs) are utilized in process industries (James, 1996).

Although production scheduling has been traditionally addressed by management science, operations research, and industrial engineering, its complexity and importance