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Using MLP networks to design a production scheduling system

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Abstract

This paper investigates the application of artificial neural networks to the problem of job shop scheduling with a *scope* of a deterministic time-varying demand pattern over a fixed planning horizon. The *purpose* of the research is to design and develop a job shop scheduling system (a scheduling software) that can generate effective job shop schedules using the multi-layered perceptron (MLP) networks. The contributions of this study include designing, developing, and implementing a production activity scheduling system using the MLP networks; developing a method for organizing sample data using a denotation bit to indicate processing sequence and processing time of a job simultaneously; using the back-propagation training process to control local minimal solutions; and developing a heuristics to improve and revise the initial production schedule. The proposed production activity schedule system is tested in a real production environment and illustrated in the paper with a sample case.

Keywords: Multi-layered perceptron; Artificial neural networks; Manufacturing; Production activity scheduling; Operations management

1. Introduction

This paper investigates the application of artificial neural networks to the problem of job shop scheduling with a *scope* of a deterministic time-varying demand pattern over a fixed planning horizon. The *purpose* of the research is to design a production activity scheduling system (a scheduling

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software) that can generate effective job shop schedules using the multi-layered perceptron (MLP) neural networks. The expected contributions include: (1) designing, developing, and implementing a production activity scheduling system using MLP networks; (2) developing a method for organizing sample data using a denotation bit to indicate processing sequence and processing time of a job simultaneously; (3) using the back-propagation (BP) training process to control local minimal solutions; and (4) developing a heuristics to improve and revise the initial production schedule.

Job shop scheduling is a decision-making process that plays an important role in manufacturing firms [1]. A job shop usually has n jobs that will be processed on m machines. A job shop does not have a predetermined sequence for workflows. Workflow is not unidirectional in a job shop. Jobs can be processed on machines in any order. Job shop scheduling applies at the level of the individual work center, where schedulers need to know which jobs are in the queue or will be in the queue soon and should be scheduled and dispatched next. The objective of control production activities in a job shop is to schedule and dispatch jobs, to determine starting times of operations sharing the same machine for each machine, and to optimize resource utilization. The commonly used performance criteria for the job shop scheduling problem include due dates management, average WIP inventory, makespan, and reliability [2].

Three approaches have traditionally been applied to solving job shop scheduling problems. They are priority rules, combinatorial optimization, and constraints analysis [3]. Each has its merits and weakness. The priority rules approach provides feasible scheduling solutions but they may not be optimal. The combinatorial optimization approach provides optimal solutions but may not have a solution for every scheduling problem, especially for the large-scale problems. The constraints analysis approach provides a set of feasible solutions that meet certain technical requirements for the scheduler to choose from [3,4]. Again, this approach does not guarantee an optimal solution.

In recent years, with the advancement of computer technology, both researchers and practitioners have turned to the knowledge-based problem solving approach to search for effective job shop scheduling methods [5–15]. The job-shop scheduling problem is an NP-complete problem and is usually very hard to find the optimal solution. An adaptive neutral network approach is able to provide feasible solutions through adapting its connection weights and biases of neutral units.

The research we conducted is based on the production activities of a manufacturing firm. Each job has its own product design and its technical information is very complicated. The product design information is often not available at the time the job should be dispatched and this situation causes delays in the firm's production planning and control. The firm does not have a standardized BOM for all its products and the computer-aided process planning (CAPP) software is not available [6,16]. Our objective is to design a production activity scheduling system (PAS) that can be used in a job shop manufacturing environment to improve production performance such as due dates management, lead time and reliability so as to improve the firm's overall profitability. We also consider the cost of hardware that the production activity scheduling software will require once the software is put into use. Considering both the scale of the network and the efficiency of the PAS system, we decide to employ the MLP networks to solve the day-to-day job shop scheduling problem.

The paper is organized as follows. Section 2 provides background information about the MLP and job shop scheduling. Section 3 presents the neural network algorithm that is embedded in the PAS system and the solutions to some technical problems related to the system. An