Int J Adv Manuf Technol (2005) 27: 321–328
DOI 10.1007/s00170-003-2184-y

ORIGINAL ARTICLE

Der-Chiang Li · Chihsen Wu · Fengming M. Chang

Using data-fuzzification technology in small data set learning to improve FMS scheduling accuracy

Received: 17 December 2003 / Accepted: 22 March 2004 / Published online: 20 April 2005

Abstract Production decisions in real dynamic flexible manufacturing systems (FMS), especially in the early stages are often made with limited information. Information is limited because scheduling knowledge is hard to establish in such an environment. Though the machine learning technique in the field of Artificial Intelligence is thus used for this task by many researchers, this research is aimed at increasing the accuracy of machine learning for FMS scheduling using small data sets. Approaches used include data-fuzzifying, domain range expansion, and the application of adaptive-network-based fuzzy inference systems (ANFIS). The results indicate that learning accuracy under this strategy is significantly better than that of a traditional crisp data neural networks.

Keywords ANFIS · Flexible manufacturing system · Machine Learning · Scheduling · Small data set

1 Introduction

1.1 Scheduling in dynamic FMS

Scheduling for production planning and control is important to reduce production cost and balance machine loads. However, unlike traditional mass production systems, the manufacturing environment is much more complex and dynamic in a flexible manufacturing system (FMS). Scheduling techniques in such an environment needs flexiblity to modify or change during the period production.

D.-C. Li (✉) · C. Wu
Department of Industrial and Information Management,
National Cheng Kung University,
No.1 Ta-Hsueh Road, Tainan 701, Taiwan
E-mail: lidc@mail.ncku.edu.tw
Tel.: +886-6-2757575 exit 50211
Fax: +886-6-2341171

F.M. Chang
Department of Industrial Engineering and Management,
Tungfang Institute of Technology,
Kaohsiung, Taiwan

Among the published approaches, the machine learning method has been widely applied in recent decades for scheduling in an FMS [1–4]. Generally, the artificial intelligence approach uses system simulations to generate examples as the experience, and applies machine learning techniques to determine the best scheduling rule for a manufacturing system [5]. The inductive learning approach is widely applied: ID3 learning algorithm [6] was used to propose a pattern directed scheduling system [7] for FMS scheduling; Pierreval and Ralambondrainy [8] proposed an inductive learning method named GENREG to reduce large number of scheduling rules; Nakasuka and Yoshida [9] introduced a learning-aided dynamic scheduler to solve scheduling problems. In addition, Chen and Yih [10] used these techniques to determine the most important attributes for constructing knowledge-based scheduling systems. Sun and Yih [11] and Sabuncuoglu and Touhami [12] applied back propagation artificial neural networks to the learning from samples.

1.2 The functional virtual population approach

In the methods mentioned above, a fairly big number of samples are usually essential for the learning system. But, there are normally only few samples in the early stages of a manufacturing system. Therefore, creating scheduling knowledge using small data set learning is gaining more and more research attention.

Li, Chen, and Lin [1] invented a functional virtual population (FVP) approach as an aid to learning scheduling knowledge using neural methods in dynamic manufacturing environments. Their FVP approach is the first proposed solution for small data set scheduling learning.

In their study, few obtained data (20) were used to build scheduling knowledge employing an artificial neural network. The scheduling knowledge was later tested for its accuracy. As expected, the accuracy is usually low since the data set is small. To solve this problem, the FVP algorithm expanded domains of the system attributes and generated a number of virtual samples. Using these virtual samples, new scheduling knowledge is constructed.