Chapter 12

RESOURCE CONSTRAINED PROJECT SCHEDULING: A HYBRID NEURAL APPROACH

Selcuk Colak, Anurag Agarwal, Selcuk S. Erenguc

Department of Decision and Information Sciences, Warrington College of Business Administration, University of Florida, Gainesville, FL 32611, USA

scolak@ufl.edu, anurag.agarwal@cba.ufl.edu, selcuk.erenguc@cba.ufl.edu

Abstract This study proposes, develops and tests a hybrid neural approach (HNA) for the resource constrained project scheduling problem. The approach is a hybrid of the adaptive-learning approach (ALA) for serial schedule generation and the augmented neural network (AugNN) approach for parallel schedule generation. Both these approaches are based on the principles of neural networks and are very different from Hopfield networks. In the ALA approach, weighted processing times are used instead of the original processing times and a learning approach is used to adjust weights. In the AugNN approach, traditional neural networks are augmented in a manner that allows embedding of domain and problem-specific knowledge. The network architecture is problem specific and a set of complex neural functions are used to (i) capture the constraints of the problem and (ii) apply a priority rule-based heuristic. We further show how forward-backward improvement can be integrated within the HNA framework to improve results. We empirically test our approach on benchmark problems of size J30, J60 and J120 from PSPLIB. Our results are extremely competitive with existing techniques such as genetic algorithms, simulated annealing, tabu search and sampling.

Keywords: Project Management, Resource Constrained Project Scheduling, Neural Networks, Heuristics

12.1 Introduction

The resource-constrained project scheduling problem (RCPSP) is a well-known NP-Hard scheduling problem (Blazewicz et al (1983)). It is a classical problem in operations research with broad applicability in project management and production scheduling. It involves minimizing the makespan of a project

by scheduling its activities which are subject to precedence and resource constraints. The amounts of available resources are fixed and known in advance. Resource requirements and processing times for each activity are deterministic and also known in advance and preemption of activities is not allowed. This problem has received the attention of many researchers for well over four decades. One of the recent research focuses in this area has been towards developing new metaheuristic approaches using artificial intelligence and/or biologically-inspired techniques. For solving this problem, two schedule generation schemes are commonly used – serial and parallel. In this work, we propose, develop and test a new hybrid metaheuristic approach based on the principles of neural networks. We use adaptive-learning approach (ALA) for serial and augmented-neural-network approach (AugNN) for parallel schedule generation scheme. We call our approach the hybrid-neural approach (HNA).

In the adaptive-learning approach (Agarwal et al (2005)), weighted processing times are used instead of the given processing times. Well-known heuristics are applied using these weighted processing times. An intelligent perturbation strategy used to adjust the weights allows non-deterministic local search. The AugNN approach was first applied to parallel schedule generation in the task-scheduling problem by Agarwal et al (2003). With suitable modifications, the AugNN approach can be applied to the parallel generation scheme for the RCPSP. The AugNN approach is quite different from the Hopfield network approach which has been applied to the traveling-salesman problem (Hopfield and Tank (1985) and job-shop scheduling (Sabuncuoglu and Gurgun (1996), Foo and Takefuji (1988)). In the AugNN approach, the traditional neural network is augmented to allow embedding of domain and problem-specific knowledge. The network architecture is designed to be problem specific; instead of the standard 3-layered network, it is a p-layered network, where p depends on the problem structure. Details will be explained in Section 16.4. Further, in the AugNN approach, the input, activation and output functions are complex functions, designed to (i) enforce the problem constraints, and (ii) apply a known priority heuristic. The AugNN approach, thus, allows incorporation of domain and problem-specific knowledge and affords the advantages of both the heuristic and iterative approaches. In this study, forward-backward improvement steps (Tormos and Lova (2001), Valls et al (2005) are also integrated within this framework of hybrid-neural approach.

We implement and test our proposed hybrid-neural approach on some well-known RCPS benchmark problem instances in the literature. Our results are very competitive with those of other techniques. Given that this approach is relatively new, it seems to hold a lot of promise; perhaps in future studies, it can be used in conjunction with other successful techniques, such as genetic algorithms, scatter search etc. to give improved results.