SCHEDULING OF MECHANICS IN AUTOMOBILE REPAIR SHOPS USING ANN

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Abstract

Scheduling problems are NP – Hard combinatorial optimization problems, since many algorithms have been developed which offers new promising insights for solving resource allocation problems. Considering the problems faced in automobile repair shops, who sets the customer due dates of the car based on processing time, jobs already waiting for processing and mechanic available time. Also the workload of the mechanic should be balanced and minimize the make-span of the work. So this paper is concerned with determination of optimal allocation of repair jobs to the mechanic using Artificial Neural Network and hence to determine the minimum Total cost and make span of repair.

Keywords: Scheduling; Repair shops; Artificial Neural Networks.

1. Introduction

Scheduling problems are NP – Hard combinatorial optimization problems, since many algorithms have been developed which offers new promising insights for solving resource allocation problems. These scheduling problems arises in a variety of services and manufacturing organizations including the scheduling of manufacturing industries [18], Call Center operators, Restaurant Table Management [11], Nurses in hospitals, doctor's appointments, Airports and Factory workers, are few among them. The solution to these scheduling problems yields benefits of lowering cost, match workload to available capacity, and smooth the flow of customers and improving productivity in organizations. The complexity involved in solving this resource allocation problem renders attracting the academia and researchers in developing new optimization algorithms [12]. This paper deals with the Goal Programming based personnel scheduling by constructing neural network model of an Automobile Repair Shop.

Repair shop environments are characterized by a greater degree of uncertainty than traditional job or assembly shop environments, and this introduces unique managerial complications. There has been several works on solving problems in Automobile repair shops. Most of them discuss only the performance management in automobile repair shops [2], [3] and [4]. Few of them discuss the algorithms in scheduling of repair shops [1], [5], [6] and [7]. Various repair scheduling approaches have been reported in the literature as shown in Table 01. The level of providing services [9], [10] and [15] as per the promised delivery schedule has been dropped for improving reliability of service quality.

In an Automobile Repair Shop, a client leaves his car to a service advisor. After a short diagnosis done by a few auto mechanics, the service advisor tells the client when his car will be fully repaired and ready to be picked up. After the client and the service advisor, both agree to the date and hour to come for the car, the car is sent inside the automobile shop for repair. Actually to avoid the difficult situations, the service advisors communicate the later time than the time estimated by the expertise team. The repair process is split into small prioritized operations and incorporated in the larger schedule. At the established due date, the client should be able to pick up the car. But it is not done in most of the practical cases due to the number of unassigned tasks or operations done by the mechanics or advisors such as enquiring the clients about repair / replace worn out parts, cars coming to repair under emergency are some among the un assigned tasks.

An artificial neural network (ANN) is a highly interconnected collection of processing units that can be trained to learn relationships between input and output patterns. A widely-used architecture for neural networks is the back propagation neural network (BPNN). This network is composed of an input layer, an output layer,

and one or more intermediate hidden layers of processing units. The processing units are linked to each other between layers by means of weighted connections. The BPNN is trained by presenting data patterns at the input layer, along with a corresponding desired output pattern for every input pattern. The connection weights between the processing units in the network are updated by using an algorithm called the back propagation (BP) algorithm [13] and [14].

This paper investigates by an artificial neural network for selecting Mechanic in a car repair shop and quoting the reliable due date to the customer by considering the various complaints raised by the customer, complaints traced out by the expert mechanics during the initial inspection, Mechanics available for service, Vehicle in queue for service and workload of individual mechanics.

2. Description of the problem:

The problem addressed in this study is daily scheduling of a service Mechanic for an automobile repair shop. The task is to assign m duties to n staff, subject to set of resources and regulatory constraints. Typically constraints are some specific duties which cannot be followed by some other duties; there must be time off and there must be starting of repair only after the arrival of the car to the repair shop and so on. A set of resources (Service advisors and Mechanics) are available for assignment to operations. Service advisors do the activities like pickup and delivery, while the mechanics do activities like repair, Oil change etc. An auto mechanic can replace service advisor if specified and needed.

In this paper, the problem illustrated by Srinivasan et al [5] is considered, while car repairs may all be distinct, we assume that the cars can be grouped into a small number of classes, each comprising of repairs with identical service time and cost characteristics. The Mechanics are assumed that there is no previous pending works to be done on the currently considered Days. The automatic generation of scheduling plans for job shops is traditionally addressed using optimization and approximation approaches [17].

Table 01 Summary of scheduled repair [8]

Schedule recovery method	**Advantages**	**Disadvantages**	**Performance measures**	**Application area(s)**
Heuristics-based Approaches (RSR& AOR)	Simple algorithm to implement. AOR has better quality schedule than RSR	Limited disruptions can be handled. Schedule quality is not recuperated after repair	Make span Starting time deviation	Job shop that is usually stable with minor disruptions at prolonged intervals. Technological constraints & processing times are predetermined and fixed
Multi agents in distributed artificial intelligence	Complete automated Approach Module for repair, refinement and rescheduling. Responsiveness of system is good Multi-threaded operations are possible	Coordination between the agents is difficult to achieve	Better integration between human and automated agents is difficult to achieve. Computation time reactiveness and schedule quality measures	Dynamic job shop with uncertainties and random disruptions
Knowledge-based scheduling and artificial intelligence approaches				
Case-based reasoning (CBR)	Well suited to domain-specific problems. Continuous learning from past cases Multiple disruptions can be modeled and addressed	Extensive search through the database consumes Time. An extensive experience database is essential	Reactive efficiency in terms of deviation from the original schedule	Job shops where Scheduling experience is available in the form of an expert's advice or a case database
Constraint-based scheduling	Human interaction and supervision is better. Timely response is possible in stipulated time frame. Performs better than	Real-time approach needs further refinement. Multiple agent architecture is needed for multi-threaded	CPU time (execution responsiveness), schedule quality measures and repaired weightage tardiness	Dynamic job shops with multiple disruptions

	CBR as it includes both knowledge base and constraint satisfaction modules	operations for random disruptions		
Fuzzy logic	Complete scan of the schedule for constraint violation after every repair. Random processing times can be used for disruptions. Response is fast as the same module is used for schedule generation and repair	Knowledge of the domain has to be built into the algorithm. Learning and growth of the algorithm is not possible	CPU time (execution responsiveness), schedule quality measures and Repaired weightage tardiness	Job shops with variability in processing time and large number of constraints to be adhered to either fully or partially
Neural Network	Response time is very fast for trained neural net Predictions are extrapolated from the past experience and are reliable	Carefully prepared training sets are needed for accurate prediction Extensive knowledge base and expert advice has to be formulated in the form of a knowledge base	CPU time (execution responsiveness) Schedule quality measures and repaired weightage tardiness	More applicable in job shops with a continuous flow and repetitiveness in the type of disturbances

Table 02 – Case Study - Srinivasan et al [5]

Day	Car	Tasks	Priority	Arrival Time
Day 1	Car 1	Fix Transmission	1	0
		Tune up	1	0
	Car 2	Fix Brakes	1	0
		Fix Transmission	1	0
		Replace Gasket	1	0
	Car 3	Replace Gasket	1	5
		Fix Brakes	1	5
	Car 4	Fix Transmission	1	5
		Change Muffler	1	5
	Car 5	Fix Fender	1	4
		Oil change	1	4
		Fix Brakes	1	4
Day 2	Car 1*	Fix Brakes	1	0
		Replace Gasket	1	0
	Car 2*	Replace Gasket	1	2
		Fix Brakes	1	2
	Car 3*	Fix Transmission	1	3
		Replace Gasket	1	3
	Car 4*	Fix Fender	1	5
		Oil change	1	5

* Simulated data *for validating the network*

1. The characteristics of the problem

The scheduling problem described above can be characterized as follows:

(i) The total of m full time Mechanics are to be scheduled.
(ii) The service of the Mechanic cannot be stocked for inventory: if there is no service request, the Mechanic is idle. We cannot save the idle time of the Mechanic for a busy time later.
(iii) Each Mechanic is flexible and can handle any type of repair.
(iv) Each Mechanic must have enough time off in a day. These day offs are not necessarily consecutive and Mechanics should not be over loaded.

(v) Each Mechanic has to start his work only after the arrival of the car to the repair shop and no preemption is allowed.
(vi) Mechanic is selected based on minimum workload and those have earliest finish time of job.
(vii) Tasks are optimally assigned to Mechanic based on minimal cost and make-span.

Table 03 – Mechanic Cost Time Data

Mechanic		Time Duration (Hrs.)						
	Cost / Hr.	Brakes	Gasket	Tune up	Transmission	Oil Change	Fender	Muffler
Joy	3	2	2	3	2	2	1	1
Luke	1	3	2	4	4	3	2	2
Sam	3	1	2	3	3	1	1	2
Dan	2	3	2	3	2	3	2	3
Ed	2	3	3	2	3	1	1	1
Davis	2	3	3	2	3	2	2	2
Cristy	2	3	3	2	3	3	2	3
Adam	3	3	4	2	3	2	1	1
John	2	1	2	3	3	2	3	3
Kamal	1	3	3	2	2	2	1	1

Table 04 – Mechanic Availability Data

Time	Joy	Luke	Dan	Sam	Ed	Davis	Cristy	Adam	John	Kamal
(0-1)	NA	NA	NA	NA	NA	A	A	NA	A	NA
(1-2)	NA	A	NA	NA	NA	A	A	NA	A	NA
(2-3)	NA	A	NA	A	A	A	A	NA	A	NA
(3-4)	A	A	A	A	A	A	NA	A	A	A
(4-5)	A	A	A	A	A	A	NA	A	A	A
(5-6)	A	A	A	NA	A	NA	NA	A	NA	A
(6-7)	A	A	A	NA	A	NA	A	A	NA	A
(7-8)	A	A	NA	NA	NA	NA	A	NA	A	NA
(8-9)	NA	A	NA	A	NA	A	A	NA	A	NA
(9-10)	A	NA	A	A	NA	A	A	A	NA	A
(10-11)	A	NA	A	A	A	NA	NA	A	NA	A
(11-12)	A	NA	A	A	A	NA	NA	A	NA	A
(12-13)	NA	A	A	A	A	A	A	A	A	A
(13-14)	NA	A	A	A	A	A	A	NA	A	NA
(14-15)	NA	A	A	NA	NA	NA	NA	NA	A	NA
(15-16)	NA	A	A	NA	NA	NA	NA	NA	A	NA

3. Experimental result:

The Table 02 shows the input given for training the network of ANN. Table 03 and 04 indicates the Mechanic cost time and his availability data respectively. Table 05 shows the input data of the day whose output has to be simulated using ANN. For the purpose of training the software we have provided thirty days input, target and output data and thirty first day input is given as the simulation input.

As per the simulated output, a total of five cars arrived with various problems as coded in the job column, The jobs 1,2,3,4,5,6 and 7 represents brake fixing, gasket, tune up, Transmission, oil change, muffler and Fender respectively. For these problems the operators are assigned as shown in the operator assignment column. The flow time column represents the time required for the repairing each car. Using ANN the jobs can be assigned to the Mechanics and due date of the work can be quoted with minimum time.

Fig. 01 Assignment of work load to the Mechanic

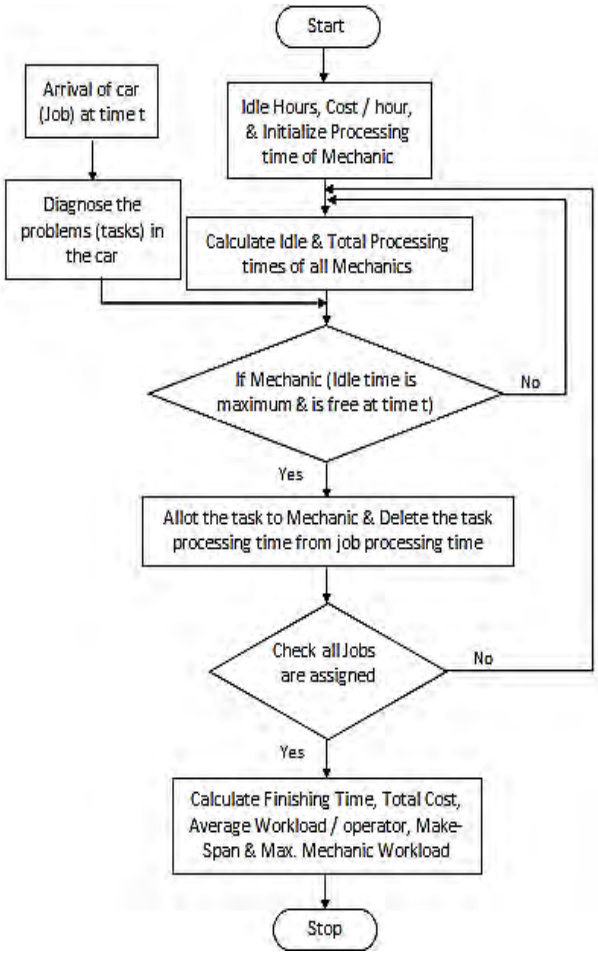

Fig. 02 Main steps in construction of an ANN

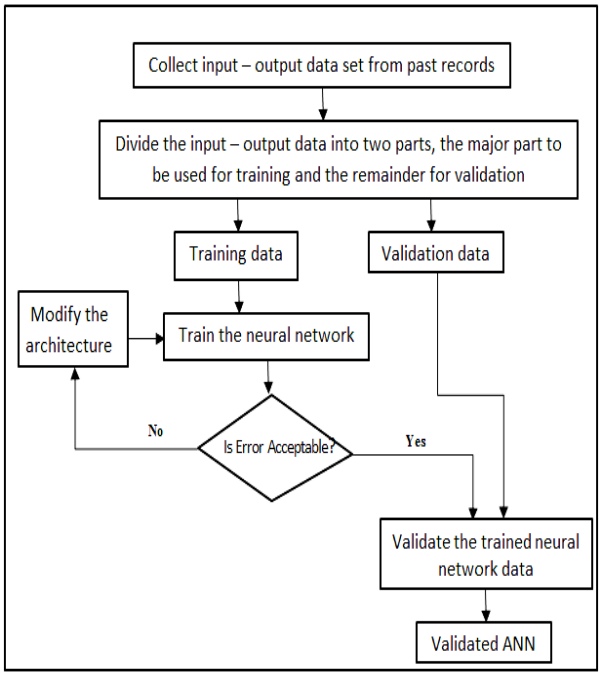

Table 05- Input and simulated output

Input Data				Simulated Output				
Day	Car No.	Arrival Time	Job	Operator No.	Starting Time	Finishing Time	Flow Time	Labor Cost
31	1	0	6	6	0	2	5	4
31	1	0	3	5	2	5		6
31	2	1	5	10	3	5	4	2
31	3	1	1	2	1	2	7	1
31	3	1	5	9	2	5		6
31	3	1	7	4	8	10		4
31	4	3	4	8	3	5	5	6
31	4	3	6	3	5	6		3
31	4	3	5	1	6	8		6
31	5	6	2	4	8	11	10	6
31	5	6	1	2	12	13		1
31	5	6	7	9	13	16		6

4. Conclusion

The scheduling process in the automobile work shop has been done successfully using Artificial Neural Network in MATLab. We considered thirty days in and out process at the work shop as the input, target and output data. Based on these data's a neural network has been created and successfully trained. Based on the next day's unknown input data, the output is simulated. The output data was decoded and verified, which was satisfactory and the allocated labor schedule constraints is also satisfied. The final output was finitely discrete to perfection. The process is really reliable in a workshop or an industry, where frequent and repeated jobs are done. Manual scheduling can be avoided by implementing this technique, which offers greater accuracy. Systematic allocation of jobs would eliminate the bias, which may prevail in manual or other type of allocation. Altogether this technique shows greater application and upper hand than any other process of its types.

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