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Minimize the Makespan in Flow Shop Scheduling Problems Using African Wild Dog Algorithm

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Abstracts

This paper considers 'n' jobs 'm' machines flow shop scheduling problems. Most real world scheduling problems are NP-hard in nature. The objective of this paper is to find minimum makespan in a serial multiple machines manufacturing system and all the jobs are flow in one pass manner. Generally, processing of 'n' jobs by 'm' machines is solved by Gantt chart method, which gives an active feasible schedule. The proposed African Wild Dog Algorithm is capable of providing better/optimal result than the approximation results.

Keywords: Scheduling, flow shop, Gantt chart, African Wild Dog Algorithm, Makespan.

Introduction

Scheduling plays vital role in manufacturing and service industries. Effective scheduling techniques should be required for improving the efficiency of industries. Different types of scheduling problems addressed in the literature. This paper considers flow shop scheduling problems to minimization of makespan time with batch size of 100. The flow shop is multiple machines environment of 'n' jobs 'm' machines. Each job has to be processed first at machine 1, then machine 2 and so on. The scheduling problem in a flow shop scheduling problem using AWDA algorithm has been the subject of considerable research. The flow shop scheduling model was first developed by Johnson [1]. Johnson developed an exact algorithm to minimize the makespan for 2-machines flow shop scheduling problems. The flow shop scheduling problem has been proved to be NP-hard [2]. Due to the complexity of the problem, it is difficult to develop exact methods to solve this problem. Hence, researchers proposed different heuristics and meta-heuristics to solve the flow shop scheduling problems. The important heuristics were developed by Rajendran and Chaudhri [3] and also proposed to solve the flow shop scheduling problems. A greedy heuristic algorithm was addressed by Baraz and Mosheiov [4] to minimize the makespan for no-idle flow shop scheduling problems. Pan et al [5] developed a hybrid discrete particle swarm optimization algorithm for solving the no-wait flow shop scheduling problem with makespan criterion. Qian et al [6] proposed a differential evolution (DE) algorithm to solve the flow shop scheduling problems to minimize the makespan. Jarboui et al [7] proposed a hybrid GA to solve the flow shop scheduling problems. Akhshabi et al [8] proposed a parallel genetic algorithm to minimize the makespan of flow shop scheduling problems. Marichelvam and Geetha [9] applied the AWDA algorithm to minimize the makespan in flow shop scheduling and compared to the other meta-heuristics. This paper optimized the makespan time with the batch size of 100 in multiple machines flow shop scheduling problems using AWDA algorithm.

Problem definition and objective function

A flow shop scheduling is characterized by unidirectional flow of work with a variety of jobs being processed sequentially in a one-pass manner. A flow shop is which 'n' jobs to be processed through 'm' machines environment. The processing times of all the jobs are well known in advance and all the jobs are processed in the same order in various machines. A particular set of jobs can be sequenced through all the machines and each sequence will have an objective function as makespan time with the batch size of 100. It is difficult to suggest a sequence, which will optimize the makespan time. In this paper, proposed the AWDA algorithm which will optimize the sequence so as to achieve minimum value of makespan time with the batch size of 100.

$$C_{max} \geq C_{im} \; for \; all \; i = 1,2,3 \ldots \ldots . n \qquad Equ\ (1)$$

Notations

C_{max} – Minimization of Makespan Time

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C_{im} – Completion time of the job (i) on machine (m)

n – Number of jobs

Illustration of NPS

A Gantt chart developed for generating Permutation Schedules (PS) can yield solutions of good quality in a flow shop scheduling problems. But the solutions may not be satisfactory. Because, the job has to follow a fixed operation sequence at each machine even though there is required operation for the job at all machines. Therefore, a better schedule performance can usually be obtained by allowing jobs to change the operation sequence at different machines like Non Permutation Schedule (NPS).

African wild dog algorithm

In the past two decades researchers have addressed several meta-heuristics to solve a wide variety of optimization problems. African wild dog animal algorithm (AWDA) is a recent, population-based meta-heuristic optimization algorithm developed by Subramanian et al [10] in 2012 for solving continuous optimization problems. The main advantage of the AWDA is it requires only two parameters. But, other meta-heuristics consists of several parameters. The AWDA is conceptualized using the communal hunting behavior of African wild dogs. In general, the African wild dogs live in groups. Each group consists of upto 20 adults and their dependent young. Communal hunting is one of the most prominent aspects of the behavior of social carnivores. The studies of carnivore ecology suggested that communal hunting might favour sociality, either by increasing the size of prey that could be killed or by improving hunting success. One can see the coordination between the members of an African wild dog group throughout the hunting process. The effectiveness of hunting depends on the number of cooperating hunters. This communal hunting behavior is similar to the optimization process. The location of each dog compared to the prey determines its chance of catching the prey. Similarly, the objective function value is determined by the set of values assigned to each decision variable. The new wild dog algorithm is developed based on a model of cooperative hunting of animals when searching for food. The African wild dog algorithm consists of the following steps.

STEP 1: Define the optimization problem and the parameters

In this step we define the objective function. The objective function is the minimization of makespan. The AWDA consists of only two parameters. The parameters are the number of wild dogs (N) and the stopping criterion. The stopping criterion is the number of iterations (I). The parameters are shown in Table.1.

Table 1 Parameters for AWDA algorithm

Parameters	Value
Number of Wild Dog	30
Number of Iterations	100

STEP 2: Randomly initialize the wild dog pack

In the steps, the position vectors for the wild dogs are generated. In general, the position vectors are uniformly distributed in between [0-1].

STEP 3: Evaluate the fitness of all wild dogs

Based on the position values, the objective function values are calculated. Then the fitness values are also calculated.

STEP 4: Coordinated movement of wild dog pack

The dog (d) will move to the new position d_{i+1} towards another dog (D) whose fitness function value is higher than that of dog (d). This step in the AWDA is similar to the PSO algorithm. The new positions are calculated as follows,

$$d_{i+1} = d_i + rand * (d_i - D_j) * c * \left({}^{a}/_{b}\right) \qquad Equ\ (2)$$

Notations

a - Mean Euclidian distance of all dogs

b - Euclidian distance between dogs d and D

c - Step reduction parameter

STEP 5: Repeat steps 3 & 4 until the termination criterion is satisfied

Most of the researchers use the number of iterations as the termination criterion. In this paper, adopt the 100 number of iterations as the termination criterion.

Gantt chart

A Gantt chart is a type of bar chart, which illustrates a project schedule. Gantt charts show the start and finish dates of the terminal elements and summary elements of a project. Terminal elements and summary elements comprise the work breakdown structure of the project. Modern Gantt charts also show the dependency (i.e., precedence network) relationships between activities. Gantt charts can be used to show current schedule status using percent-complete shadings. This chart is also used in scheduling to find out Permutation Schedule (PS).

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Computational results

African wild dog algorithm was coded in java and run on a corei3 processor 2.40 GHz PC with 6 GB memory. In the experiment, generated the 10 specific problems sets and tested with 100 batch sizes. The processing times were random integers from a uniform distribution p(i,j), U[1-99]. The influence of job size on execution time is significant. Table 2 represents the result of 10 specific problem test sets with batch size of 100 in flow shop scheduling problems.

Table 2 Minimize the makespan time in 10 specific problem test sets with batch size of 100

S.No	n x m	Gantt Chart Results	AWDA Results
1	20 x 2	3273	3150
2	25 x 2	4682	4215
3	50 x 2	6841	6024
4	75 x 2	7958	7162
5	100 x 2	8245	7513
6	20 x 5	5742	4821
7	25 x 5	7150	6618
8	50 x 5	8235	7700
9	75 x 5	8527	7945
10	100 x 5	9514	8423

Conclusions and future work

The flow shop scheduling problems for minimizing the makespan is modeled. The proposed AWDA is illustrated and experimented with 10 different sample problems to be conducted. The AWDA yields near optimum results than the Gantt chart results. The future research efforts need to be focused on the development of hybrid combinatorial algorithms for solving more complex flow shop problems involving setup times, total flow time, inter-stage transport times, release dates and due dates.

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