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Application and Significance of Firefly Algorithm for Multi-Objective Job Shop Scheduling

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***Abstract*- Present Study emphasis on the traditional scheduling problem of machines and jobs with modern solution technique. Job Shop scheduling is one of the typical types of traditional & dynamic scheduling problem. This research work focused on the application and use of a new nature inspired approach *Firefly Algorithm* based on the intensity of light of fireflies as solution and optimization technique for the scheduling problem. In this paper we proposed a meta-heuristic to solve the multi-objective job-shop scheduling problem. Introduced solution approach follows the flashing behavior of the fireflies to explore the global best among all locals. A comparative validation is also made in this research work with some benchmark problems. The results outcomes focused and clearly show the effectiveness of this approach to meet the solution for the multi objective job shop scheduling problems. For the representation of solution for an individual problem Gant chart is used, it provides clear visualization for the optimal solution obtained and to aid comparison with other solutions.**

***Index Terms*- job shop scheduling, Firefly Algorithm, Benchmark, metaheuristic.**

I. INTRODUCTION

Scheduling problem is a decision making process involving the allocation of resources over time to perform a set of activities or tasks. Scheduling is one of the most important issues in the design of production system; it has gained much attention in the recent years. In other way scheduling determine when a job is to be started on a machine and when it is to be completed.

The principle aim of scheduling is to plan the sequence of work so that production can be systematically arranged towards the end of completion of all products by due date. The proper scheduling of machines in an industry can reduce the production hours that contributes to produce goods much faster. Job shop scheduling is one of the most famous scheduling problems, most of which are categorized into NP hard problem. This means that due to the combinatorial explosion, even a computer can take unacceptably large amount of time to seek a satisfied solution on even moderately large scheduling problem.

I. Job shop scheduling problem (JSSP) is comprised of a set of independent jobs or tasks (*J*), each of which consists of a sequence of operations (*O*). Each operation is performed on machine (*M*) without interruption during processing time.

II. The main purpose of JSSP is usually to find the best machine schedule for servicing all jobs in order to optimize as the minimization make span, machine idle time, and total tardiness.

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II. FIREFLY ALGORITHM

This is a recently proposed metaheuristic algorithm by xin-she yang. Recent studies show that this algorithm is very efficient and could outperform another metaheuristic algorithm like particle swarm optimization and genetic algorithm. The algorithm has been developed from the flashing behaviour of fireflies. Firefly Algorithm (FA) is a nature inspired algorithms, which is based on the flashing light of fireflies. The flashing light helps fireflies for finding mates, attracting their potential prey and protecting themselves from their predators. The swarm of fireflies will move to brighter and more attractive locations by the flashing light intensity that associated with the objective function of problem considered to obtain efficient optimal solutions.

The primary purpose for a firefly's flash is to act as a signal system to attract other fireflies. Xin-She Yang formulated this firefly algorithm by assuming:

- All fireflies are unisexual, so that one firefly will be attracted to all other fireflies.
- Attractiveness is proportional to their brightness, and for any two fireflies, the less-brighter one will be attracted by (and thus move to) the brighter one; however, the brightness can decrease as their distance increases.
- If there are no fireflies brighter than a given firefly, it will move randomly.

III. Methodology

The decision variables used in the job shop scheduling problem are:$_{qijk}$: Completion time of job j on machine i in k^{th}order x_{jk}: Binary variable taking value 1 if job j is processed in k^{th} order and 0, otherwise. The mathematical model for minimizing the makespan is as follow:

Multi-objective function:

$$\text{Min} \quad \sum_{j=1}^{n} q_{mjn} \cdot x_{jn}$$

Subject Constraints:

$$\sum_{k=1}^{n}(q_{(i+1)jk} - t_{(i+1)j})x_{jk} \ge \sum_{k=1}^{n} q_{ijk}\, x_{jk}, \qquad i = 1, \ldots, m-1; j = 1, \ldots, n$$

$$\sum_{j=1}^{n}(q_{ij(k+1)} - t_{ij})x_{j(k+1)} - \sum_{j=1}^{n} q_{ijk}\, x_{jk} \ge 0, \qquad i = 1, \ldots, m; k = 1, \ldots, n-1$$

$$\sum_{j=1}^{n} x_{jk} = 1, \forall\, i, k \sum_{k=1}^{n} x_{jk} = 1, \forall\, i, j$$

$$q_{ijk} \ge 0, \forall\, i, j, k$$

$$q_{ijk} \le M x_{jk}, \forall i, j, k$$

$$x_{ijk} = \{0,1\}, \forall\, i, j, k$$

IV. MOFA APPROACH TO SOLVE MJSP:

Step1: Initiating control parameters No. of fireflies (l), absorption coefficient (γ), randomized parameter (α), initial attractiveness (β_0) and the number of iterations k.
Step2: Firefly initialization randomly initializes all the fireflies whose dimensions are equal to total of all operations of all the jobs.
Step3: Finding the feasible operation sequence using the firefly initialization a feasible operation sequence is obtained. Each magnitude, of direction, is considered as priority to the operation, according to the priorities and the precedence of the operations, in a job, a feasible operation sequence is formed
Step 4: Assigning of operations to the machines First, a sequence of the capable machines of an operation according to the increasing order of processing time is formed. If one machine's processing time is equal to another, the lower order number of machine has priority. After this course, we get different priority levels for all machines which process the same operation. Then the particle position can be generated stochastically according to the order of operations of different jobs.
Step 5: Evaluation of function According to the operation sequence and the corresponding assignment of the operations on the machines, the above considered functions are evaluated.
Step 6: Compare each firefly and move the firefly In this step firefly is compared to one other based on the function F and all the fireflies are moved towards the best firefly. When a firefly is moved towards the other a new position is attained by this the priorities are changed. By this the feasible operation sequence is changed.
Step 7: Obtain the best solution. The Step 3 to Step 6 are executed for several iterations. After all iterations the minimum function value, its operation sequence and the corresponding assignments is obtained. During pair wise comparison loop, the best-so-far solution is iteratively updated. The pair wise comparison process is repeated until termination criteria are satisfied.

V. RESULT AND DISCUSSION

Table: 1 Comparison of the results of 6x6 FT(06) problem

Problem 6×6 FT(06)	MO GA	MOP SO	MO FA
Makespan	76	56	55
Total idle time	259	100	95
Tardiness	31	3	4

Table: 2 Comparison of the results of 10x5 LA (01) problem

Problem (10x5) LA(01)	MOG A	MOP SO	MO FA
Makespan	1256	709	688
Total idle time	3431	521	477
Tardiness	3324	721	780

Table: 3 Comparison of the results of 10x5 LA (03) problem

Problem 10x5 LA (03)	MOG A	MOP SO	MO FA
Makespan	821	671	638
Total idle time	1722	633	326
Tardiness	3324	373	410

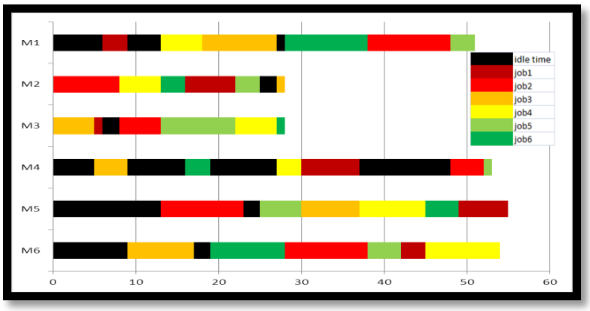

Fig 3.1 Gantt chart for 6x6 FT (06) problem

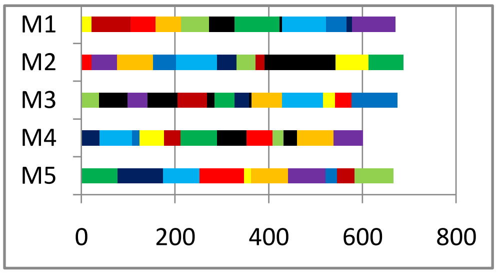

Fig 3.2 Gantt chart for 10x5 LA (01) problem

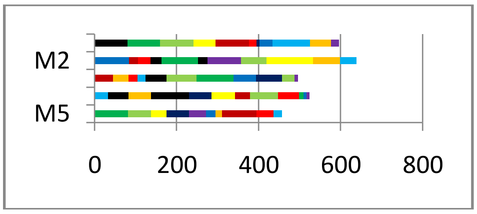

Fig 3.3 Gantt chart for 10x5 LA (03) problem

VI. CONCLUSION

Recently, multi-objective job-shop scheduling problem has attracted many researchers attention. The complexity of this problem leads to the appearance of many heuristic approaches. In this study, a firefly algorithm is proposed to solve the job shop scheduling problems with multi objectives of minimizing makespan, the total idle time of machines and total tardiness of the jobs by firefly algorithm, a newly proposed meta-heuristic. The performance of the presented approach is evaluated in comparison with the results obtained from other authors' algorithms for three representative instances. The obtained results show the effectiveness of the proposed algorithm.

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