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Evaluate Flexible Job Scheduling Problem Using Elitist Ant

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Abstract. One significant approach that is frequently utilized in many applications, particularly in industry, is scheduling .An extension of job scheduling, the Flexible Job Shop Scheduling Problem (FJSP), has a number of real-world uses .This subject has received a lot of attention due to its significance and complexity .This research discusses the importance of scheduling in real-life operations, particularly in production scheduling. It presents a model using Elitist Ant (EAS) to compute the maximum value (makspane) of the flexible job shop scheduling problem(FJSP). The model programmed by Python ver. (3.) with two instance from Brandimarte dataset to optimize logistics costs and meet customer demand. The study deduce that there are two relations by using two new formula. Firstly, the relation between number of elitist ant and total ants . Also, the evaporate value is effected by the first relation directly.

1 Introduction

In Real Life, All operation in earth are depending on the scheduling . production Scheduling is the importance steps which are depending on the make decision daily. It means distribution productions , transport and orders over the world quickly with minimum Costs [1].

Job Shop Scheduling problem (JSP) is the NP-hard optimization problem and production Scheduling it describes as there are many tasks or operations that distributed on many resources or machines t that reached with a specific costly plan with predefine or not the sequence steps [2]

Flexible Job Shop Scheduling problem(FJSP) is a type of JSP which means there are many task handled on a set of resources or machine , each task consist of many operation with a specific order [3]

A meta heuristic is a set of heuristic algorithm that can be modified to reach the optimal solution with a local search in deferent optimization problems, meta heuristic can understand higher-level algorithmic framework which is problem independent and equipped with a set of strategies to develop heuristic optimization algorithms [4]

Ant Colony Algorithm (ACO) is a meta heuristic optimization problem based on Ant Colony behavior with a positive feedback , probabilistic algorithm used to reach the optimal route in the search space depending on the amount of pheromone of the ants that laid on the rout when searching a source food [5][6] .

2 Related work

Many intelligent algorithms have been applied to combinatorial optimization problems, such as genetic algorithm (GA) [7], Bayesian algorithm [8], ant colony optimization (ACO) algorithm [9], Artificial Bee Colony algorithm[10], Grey Wolf Optimization[11] , Qian WANG et al [12] they proposed a multi-factor optimization-ant colony hybrid algorithm for flexible job shop scheduling, focusing on distribution of processing procedures and reducing production costs and processing time. The model achieves high execution efficiency and convergence speed. Matrenin [13] discussed the improvement of the Ant Colony Optimization algorithm for Job-Shop Scheduling Problem using Evolutionary Adaptation and Software Realization Heuristics. It presents a graph-based representation, introduces heuristic techniques, and compares its parallelization effectiveness with other scheduling problems. William Torres et.al [14] proposed a hybrid algorithm for globalized production scheduling and transportation, focusing on flexible job shop scheduling and vehicle routing. It emphasizes the importance of integrating production and transportation activities to meet customer demand and optimize logistics costs, Aleksandar Stanković et al [15] presented a model using meta-

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heuristic algorithms such as Genetic Algorithm (GA), Tabu Search (TS), and Ant colony optimization (ACO) to minimize time spent on planning and scheduling operations. The efficiency of the approach is reflected in the flexible search of space and the choice of dominant solutions. The results are graphically represented on a Gantt chart. The paper compares different meta-heuristic optimization methods, such as exact methods, constraint programming, and simulation methods, to help managers identify the most suitable method for this problem.

3 Flexible Job Shop Scheduling Problem

The NP_hard optimization problem ,It contains a set of task T ={t1,t2,t3 ….tn} are handled on a set of M machines M={m1,m2,m3, ….mm} and each task is a set of operation Oi ={O1,O2 ,…, Oim} With specific order the condition of the FJSSP are describes below:

- All operation can be performed on the machine at a time without any interrupt .
- Each machine can be processed one operation at a time , all of them started at time zero .

The objective parameters of solving FJSP are workload and makespane , maximum production profits [12] .

4 Elitist Ant Colony Optimization

Is a meta heuristic optimization algorithm which are used to solve complex NP- hard problems. It simulated the pheromone a mount that putted by the ants on the path from the nest to the food source, then accumulative to find the best route, according to the probability equation[16]. This algorithm used the elitist ants to speed up the convergence by distinguish the shortest route, which raising the pheromone trail on all of them[17].

5 Proposed model

This paper used EAS to calculate the maximum FJSP. Its general flow chart is shown in Figure (1), which shows how the proposed algorithm (EAS) works to solve the mentioned problem, where the ants make local trips to discover the correct path (the nearest machine), where only the ants that found the best solution are allowed to deposit the pheromone and then calculate the comprehensive path to get the optimal solution. The system was built using Python version (3) with the dataset (Brandimarte MK01,MK02) which described below in figure (2) . Where n is represent the jobs number and m is machine number.

Instance	n	m
MK01	10	6
MK02	10	6
MK03	15	8
MK04	15	8
MK05	15	4
MK06	10	15
MK07	20	5
MK08	20	10
MK09	20	10
MK10	20	15

Fig.1. : instance of Brandimarte dataset [18]

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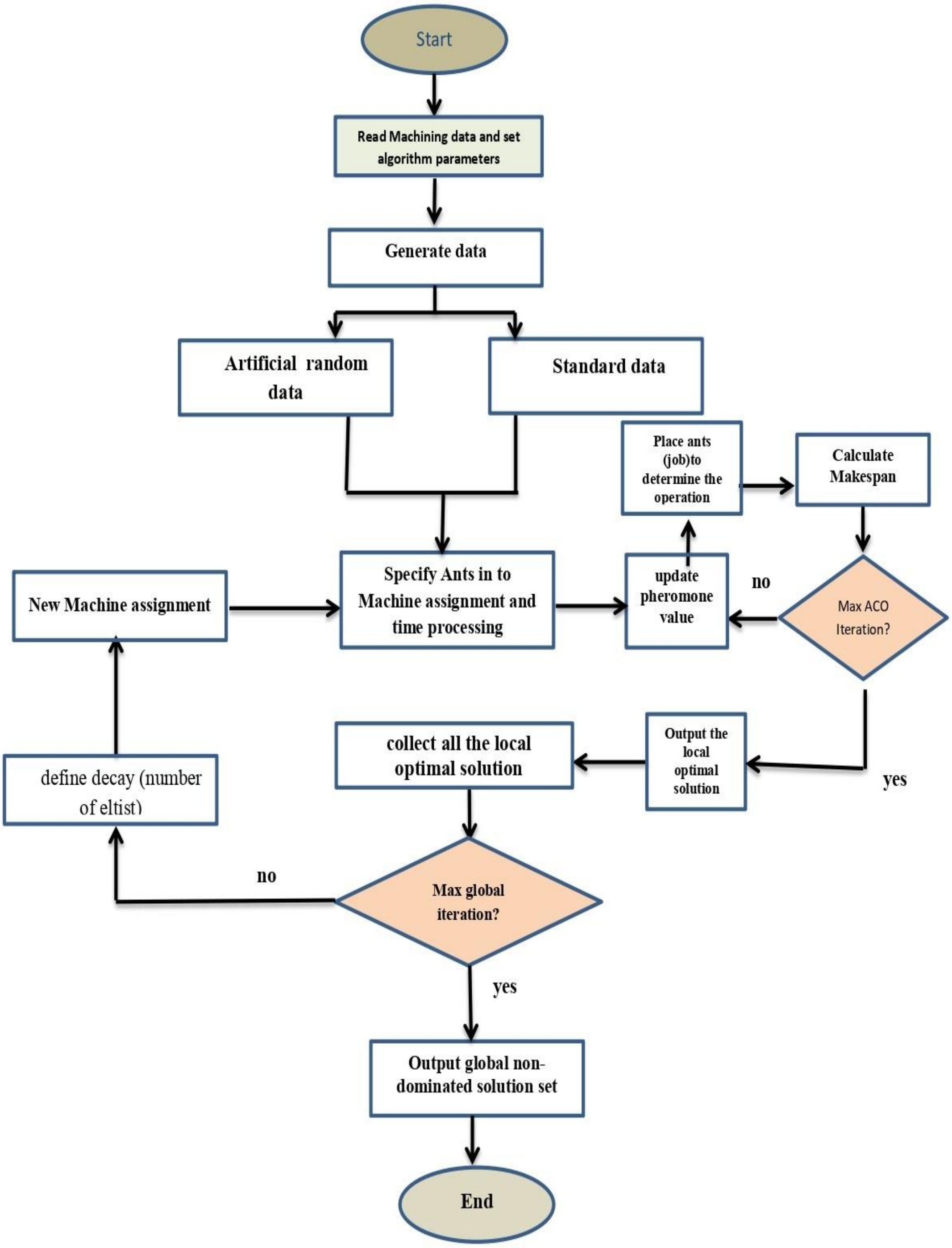

Fig.2. flowchart for proposed algorithm

The general algorithm for the system are :-
Algorithm EAS for FJSP
Input : data set for FJSP initial parameters of EAS
Output : best make span
Step 1 : initialize the main parameters of EAS
Step 2 : read data set
Step 3 : compute the pheromone values
Step 4 : calculate the heuristic value
Step 5 : select the machine randomly
Step 6 : update pheromone by using evaporate parameters

$$Pheromone = (1 - evaporate)*pheromone + \Delta\, pheromone \qquad ...(1)$$

$$\Delta\, pheromone = (constant / length\ of\ tour\ by\ ant\ k) * elitist\ ant \qquad ...(2)$$

The probability eq. are

$$Probisk\ (t) = \begin{cases} \dfrac{[pheromone\ (t)_{ij}]^{alpha}[heuristic_{ij}]^{beta}}{\sum_{i,j=1}^{n}[pheromone\ (t)_{is}]^{alpha}[heuristic_{is}]^{beta}} & if\ j \in list\ k \\ \text{otherwise is zero} \end{cases} \qquad \ldots\ldots\ldots(3)$$

Step 7 : loop for number iteration , job identifier and operation
Step 8 : compute makspane
Step 9 : select the best makspane
Step 10 : update pheromone
Step 11 : return best solution and best makspane

6 Results and discussion

Most of the researchers are not used ESA for solving FJSP . in this paper try to use it with a new eq.(4) to evaluated the relation between numbers of ants and number of iteration with elitist ants which describes below.

$$No.\ of\ elitist\ ant = 10\%\ of\ No.\ of\ ants \qquad ....(4)$$

Where number of ants is equal to number of iteration .In table (1) display the makspane for the two types of data set (Brandimarte) with alpha(α) = 1.5 Beta(β) = 0.5 for 20 times of running software . While in table (2) , the results for the same data set with α = 0.5 and β =1

From table (1,2) deduce that the results are the best when using $\alpha < \beta$ .In table (3) , apply alpha and beta are equal to (0.5) to satisfy the eq.(5)

$$Alpha + Beta = 1 \qquad ....(5)$$

Table 1. result (α=1.5, β=0.5,evp= 0.2, no. ants =100, no .elitist ant =10 , itra = 100)

No.	Mk02	Mk01
1	139	112
2	134	108
3	144	106
4	162	108
5	119	89
6	98	114
7	162	100
8	176	94
9	154	103
10	185	96
11	163	99
12	133	126
13	110	105
14	150	80
15	123	93
16	99	115
17	159	112
18	159	112
19	150	130
20	130	103

Table 2. Result (α=0.5, β=1.5, evp= 0.2, no. ants =100, no .elitist ant =10 , itra = 100)

Mk02	Mk01	No.
108	68	1
111	80	2
121	83	3
106	79	4
100	78	5
102	74	6
85	70	7
106	74	8
126	81	9
119	68	10
122	85	11
110	91	12
79	71	13
103	68	14
113	81	15
105	87	16
116	81	17
110	81	18
93	85	19
110	82	20

We show that the best value is 65 for the data set (mk01). Table 4 display the results when using the equation (6) .

Evaporate value = elitist ant number / ant number ……..(6)

The parameters used in the research paper are defined as follows:

- $\alpha \geq 0$ is a parameter to control the influence of pheromone (t) $_{ij}$
- $\beta \geq 1$ is a parameter to control the influence heuristic (t) $_{ij}$
- heuristic (t) $_{ij}$ is the reciprocal of the distance d_{ij} (k) from job i to j
- pheromone (t) $_{ij}$ is pheromone value that deposit by ant k,
- Evaporate value is evaporation coefficient of pheromone.
- Δ pheromone is the quantity of pheromone on the machine (i, j) laid by ant kth

We notice that the makspane is very low when compared with other tables for MK01 , MK02 and in figure(3) show the Gantt chart for the apply the data set (MK01).

Table 3. Result (α=0.5, β=0.5,evp= 0.2, no. ants =100, no .elitist ant =10 , itra = 100)

No.	Mk02	Mk01
1	113	85
2	114	70
3	106	76
4	112	75
5	116	78
6	105	72
7	111	79
8	103	79
9	89	71
10	108	77
11	92	86
12	100	82
13	107	84

14	125	76
15	92	89
16	97	65
17	96	65
18	99	79
19	105	71
20	111	73

Table 4. Result (α=0.5, β=0.5,evp= 0.2 , no. ants =10, no .elitist ant =2 , itra = 100

No.	Mk02	Mk01
1	110	68
2	100	74
3	105	84
4	111	75
5	105	79
6	112	85
7	111	65
8	107	81
9	104	79
10	104	77
11	98	82
12	107	81
13	104	78
14	99	67
15	100	74
16	103	85
17	105	76
18	119	85
19	95	89
20	106	79

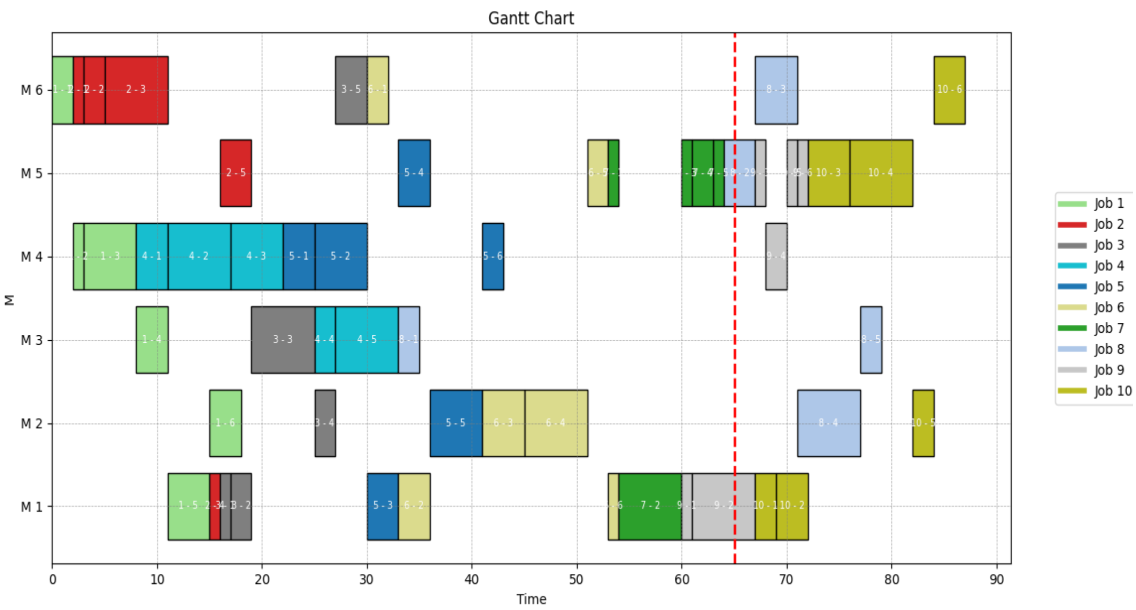

Fig 3. Gantt Chart for proposed model formk01with (10 jobs with 6 machine)

7 Conclusion

The paper discusses the importance of scheduling in real-life operations, particularly in production scheduling. The FJSP is an NP-hard optimization problem that solves by using EAS by evaluating the relation between ants' numbers with elitist ants and the evaporate rate. From the experiments , deduce that the number of elitist ants must equal to the 10% of the ants' number to give the best results for the first dataset by using the first new formula . While secondly relation is evaporate value that is equal to the division between number of elitist to the number of ants used.

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