Employee Scheduling based on Particle Swarm Optimization Algorithm and its Variation

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ABSTRACT
Scheduling problems are multi-constrained and NP-Hard problems. This paper deals with the faculty assignment problem. Objective of this paper is to assign the faculty to exam halls. This problem is tested on real world dataset from Rajarambapu institute of technology. This paper attempts to solve the problem by using particle swarm optimization algorithm and its variation and analysis of both approaches are shown.

Keywords
Scheduling, faculty assignment problem, Particle swarm optimization, discrete particle swarm optimization.

1. INTRODUCTION
Scheduling is the process of allocating or distributing work or workloads and tasks to processor, humans or machines to complete within the time constraint. Scheduling is done within the time constraints. It is allocation or distribution of the workload and tasks to processor, human or machines [1].To solving the optimization problem, there are various traditional techniques By the literature, there are various techniques are available to find out the solution on scheduling problems like tabu search [1], linear numbering algorithm [2], simulated annealing [3], quadric assignment method [4], Integer linear programming [5], iterated heuristic algorithms [6], Heuristic Procedure [7] they performances better but sometimes that are fail to solve the problems containing large no. of parameters and non-linear objective functions and also they are not sufficient to handling problems or sometimes that algorithms are get stuck to a suboptimal solution.

Particle swarm optimization algorithm is advantageous as simple, easy to implement and easy to complete and uses fewer parameters comparison also it gives better results than other algorithms [8].PSO algorithm is used for solve different scheduling problems like task scheduling in grid computing [9] ,task scheduling in cloud computing environment[10][11][12],timetable generation[13] [14] ,grid resource scheduling [15][16] ,job shop scheduling [17][18].There are different variations of PSO algorithm is present and these are listed out in paper [19].

2. PROBLEM DESCRIPTION
In the work, employee scheduling problem is attempted where the objective is to assign the faculties to exam halls by satisfying the different general and organizational constraints.

The problem is, experimented on the dataset prepared from institute's exam section of Rajarambapu Institute of Technology, Rajaramnagar (Sakharale).

2.1 Assumptions
1. Each day contains two time slots; either morning or evening.
2. For each and every day the number of blocks are not constant.
3. As the designation increases the load decreases.
4. If faculty is on duty work then he should not get the supervision.
5. Faculties are more than the exam blocks.

2.2 Objective function
Most of the optimization problems are in the form of minimization or maximizing.

The objective function for individual calculated as follows.

$$\min(z) = \sum_{i=1}^{n}(H_i * \alpha i) + \sum_{j=1}^{m}(S_i * \beta j) \qquad (1)$$

Where, Hi and Sj represent number of hard and soft constraints violated by a solution for ith hard constraint and jth soft constraint respectively. αi and βj represents penalty costs for violation of hard constraint and soft constraints respectively[1] .

The important objective is assignment of supervisor to the exam blocks by considering some conditions called constraints and that conditions should be satisfied.

2.3 Hard Constraints
Hard constraints are those that must be met. If these constraints will be violated, then the solution is not feasible [1].

1) **General Constraints**
   i. The faculty and students in the classroom should not be from same department.
   ii. Maximum workload of teacher must not be exceeded.

2) **Organizational Constraints**
   i. Each day have extra 3 teachers to allocation if needed.
   ii. If any teacher is on-duty leave, then he should not be allocated to supervision.
   iii. Each day contains two time slots; either morning or evening.

2.4 Soft constraints

Soft constraints are important to produce the good solution but violation of soft constraints is allowed.

1) **General Constraints:**

i. Each teacher has a single duty on a day (either morning or evening).

ii. Every teacher should have a different slot for all days i.e. should have either morning slot or evening slot.

2) **Organizational Constraints**

i. Balance no. of teachers from each department.

3. PARTICLE SWARM OPTIMIZATION

Particle Swarm is a non-traditional, modern optimization method. PSO was developed to solve nonlinear optimization problem, but now the algorithm has been used in many areas, and also in real-world problems.

- **Steps of PSO algorithm:**

1. Initialization of particles (n) form the solution space

2. Calculate the fitness value of each particle (swarm). (Objective function).

3. Calculate the local best (Pbest) and global best (Gbest) for each solution.

Where,

Gbest: gbest position of swarm.

Pbest: pbest position of particle.

4. Evaluate the velocity of each l particle (swarm).

$$Vj = Vj(i-1) + c1r1\,[pbest,j - X\,j(i-1)] + c2r2\,[gbest,j - X\,j(i-1)] \ldots (1)$$

Where,

c1, c2= positive acceleration coefficients.

r1, r2 = random numbers that has values between [0, 1]

5. Calculate the position of each particle.

$$X\,j\,(i) = X\,j\,(i-1) + Vj(i) \ldots (2)$$

Where,

V is the velocity component of j th particle at i th iteration.

X is the position component of j th particle at i th iteration

6. Go to step2, and repeat until a termination criterion is met.

3.1 PSO for faculty assignment problem

1. Initialization of swarms, particle number and input given to the algorithm.

2. Evaluate the fitness value according to the objective function (calculation of cost (penalty) of each solution (particle)).

3. All calculated possible solution given to the algorithm.

4. Compare all the possible solutions to the previous values and find the local and global best values.

5. Update the velocity and position according to the equation (1) and (2)

6. Update the solution until the termination criteria is met (no. of iteration) and go to step 2.

3.2 Discrete PSO

Here to improve the performance of PSO algorithm acceleration coefficients (c1, c2and c3) and velocity coefficients (u1, u2 and u3) are added in discrete PSO.

Update the velocity and position according to the equation (3) and (4).

Vt+1k = C1 U1 vtk+ C2 U2 rand () (ePt+1k- Pt+1k) + C3 U3 rand () (Gtb- Pt+1k)…. (3)

Pt+1k =Ptk-Vt+1k …… (4)

Where

C1, C2 and C3 are the acceleration coefficients. Those acceleration constants are help to every particle to move towards the local best and global best solution during the search process. [36]

The velocity updating process is carried out at each iteration to improve the solution. Namely U1, U2 and U3 are the velocity coefficients used to find the optimal solution quickly. As per the experiment, the values for U1, U2 and U3 are between 0 and 1. [36].

4. IMPLEMENTATION DETAILS AND RESULTS

Dataset is prepared on the basis of exams in RIT, Rajaramnagar (Sakharale).

Table 1: Data set used for problem

Department	No of teacher	Prof	Asso. prof	Assi prof	Ava Class.
mechanical	39	4	8	27	9
automobile	21	3	1	17	3
civil	23	4	1	18	10
computer	18	NA	1	17	3
Electrical	18	1	1	16	3
electronics	17	2	4	11	4
Info. technology	14	NA	NA	14	2

The table 1, Shows the consider data set details that is seven departments and available faculties and classrooms from all departments are 150 and 34 respectively and exam is carried out for 15 days. Second column shows the total number of available teachers from each department. Third, Fourth and Fifth column shows the total number of available professors, associate professors and assistant professors from particular department's resp. and last column shows the total available classrooms from each departments.

The goal of this work is to prepare schedule to satisfy the all general and organisational constraints as well as to full fill the expectations of teachers.

Table 2 contains the parameters i.e. iteration number, number of particles and fig 1 shows the performance of basic particle swarm optimization and discrete particle swarm optimization in terms of time taken to complete the task.

Table 2: Iterations versus time

Iteration no.	Time taken to complete task (min)	
	PSO	DPSO
10	7.26	2.11
30	8.91	3.96
50	13.2	6.03
70	15.64	7.01
100	20	9.82

Table 3: iterations versus Cost

Iteration no.	Cost (Penalty)	
	PSO	DPSO
100	45	34
300	39	35
500	29	27
700	27	23
1000	9	3

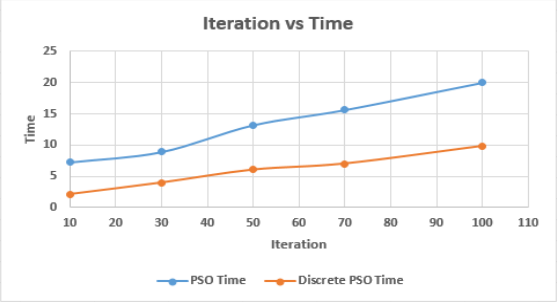

Fig 1: Iterations versus time (iterations= 10, 30, 50, and 100)

The experimental results show that the time required to complete the task taken by particle swarm optimization is greater than discrete particle swarm optimization. As number of iteration goes on increase it takes more time for computational results.

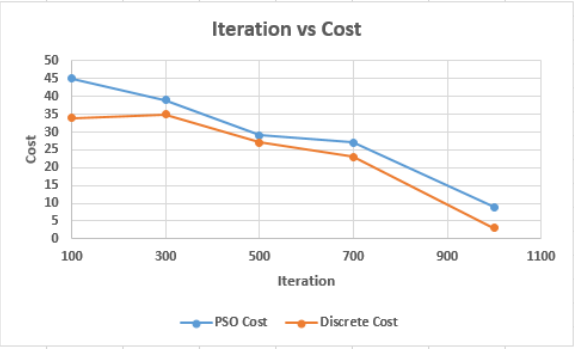

Fig 2: Iterations versus Cost (iterations= 100, 300, 500, and 1000)

The velocity coefficient of discrete particle swarm optimization has the ability to search the solution faster.

Table 3 contains the iteration number, and fig .2 shows the performance of basic particle swarm optimization and discrete particle swarm optimization in terms of penalty cost. It shows when number of iterations is increases the constraints violations are minimized.

5. CONCLUSION

Particle Swarm is a global heuristic optimization algorithm. It is inspired by birds flocking and fish spooling natural behaviour. Since many of the advantages of particle swarm, including its simple and easy to implement, use several parameters of the algorithm can be widely used in many fields.

It used in different scheduling problem. Here, Performance of both proposed approaches are analysed in terms of time and no. of constraints violations by varying the number of iterations and particle size. From the experimental results, it observed that as the number of iterations and number of particles increase, the discrete particle swarm optimization algorithm performs best in terms of time and violations of constraint (cost), because of having velocity coefficients and acceleration coefficients respectively.

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