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RESOURCE OPTIMIZED SOFTWARE PROJECT SCHEDULING USING FUZZY RANDOMIZED PSO

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ABSTRACT Projects Scheduling plays a significant role in software project management. Recently, a few research works has been designed for project scheduling and resource allocation. But, there is a need for effective scheduling model for scheduling multiple project activities with minimum cost. In order to overcome such limitation, Fuzzy Random Optimized Dynamic Mean PSO (FRODM-PSO) model is proposed to prioritize multiple project activities of multiple software projects. The FRODM-PSO model designed a Dynamic Mean Particle Swarm Optimization (DM-PSO) algorithm for prioritizing multiple projects' activities with minimal scheduling time that assure minimum cost. In DM-PSO algorithm, the weight and learning factors are measured in an iterative manner with changes in the iteration level. At the same time, the DM-PSO algorithm selects the particle with best fitness value among the all particles as best solution for scheduling the multiple project activities therefore ensuring the memory optimization. With the prioritized multiple projects' activities, a Fuzzy Random Optimization model towards multiple project scheduling using two levels of decision makers is designed for allocating the resources with higher resource optimization rate. The performance of FRODM-PSO model is measured in terms of scheduling time, memory usage and resource optimization rate. The experimental result shows that the FRODM-PSO model is able to improve the resource optimization rate by 17% and also reduces the scheduling time by 48% when compared to state-of-the-art-works.

KEYWORDS : Project Scheduling, Resource Allocation, Multiple Project Activities, Dynamic Mean Particle Swarm Optimization, Fuzzy Random Optimization Model

1. Introduction

Software project management is the process of scheduling and leading software projects wherein software projects are designed, implemented, monitored and controlled. Resource allocation and tasks assignment to software development teams are very significant and difficult activities because it affects project's cost and completion time. Recently, most of research works has been developed for project scheduling and resource allocation. For example, An Event-based scheduler (EBS) and ant colony optimization (ACO) algorithm was designed in [1] for addressing the both the problems of human resource allocation and task scheduling and providing a flexible effective model for software project planning. But, task scheduling is not carried out in efficient manner.

Particle swarm optimization (PSO) based hyper-heuristic algorithm was developed in [2] for solving the resource constrained project scheduling problem (RCPSP) to find near-optimum solutions in reasonable computational time. However, PSO method needs maximum processing time when the problem size is enlarged. A Max-Min Ant System algorithm was introduced in [3] for handling the software project scheduling problem in which ACO algorithm develops optimization method for solving discrete optimization issues in different engineering domains. Though, this algorithm does not provide better solution. A multi-agent optimization algorithm was presented in [4] for dealing the resource constrained project scheduling problem. But, large-scale problems remained unaddressed.

A genetic algorithm was implemented in [5] for optimal resource-driven project scheduling and increasing the optimization model to describes the resource consumption in construction activities. However, the size and complexity is high. A Cooperative Co evolutionary multi-objective algorithm (CCMOA) was explained in [6] to solve resource allocation and scheduling problem simultaneously. Though, the multiple types of activity and dynamic events are not developed during project execution.

Pre-scheduling heuristic (PERS²A algorithm) and Mixed-integer linear programming heuristic (SADT algorithm) was designed in [7] for addressing the difficult optimization problems and employs low computational resource to solve optimal problem. But, the operating cost was high. A multi-threaded local search algorithm was planned in [8] for solving multi-objective resource-constrained multi-project scheduling problem where it improves the several resource-duration alternatives in each activity.

Dynamic task-aware scheduling mechanism was developed in [9] to decrease the resource contention in NUMA multi-core systems. However, the problem of analyzing most appropriate tasks for migration and increase the superfluous task and page migration. An improved differential evolution (IDE) algorithm was intended in [10] for addressing the software project scheduling problem (SPSP).

In order to overcome the above mentioned existing issues such as ineffective task scheduling, higher processing time, higher operating cost and complexity, a novel model called Fuzzy Random Optimized Dynamic Mean PSO (FRODM-PSO) is designed. The key objective of FRODM-PSO model is to prioritize multiple project activities of multiple software projects with minimal resource cost.

The contribution of the research work is formulated as

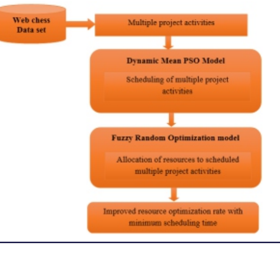
- A Dynamic Mean Particle Swarm Optimization (DM-PSO) algorithm is designed in FRODM-PSO model to efficiently scheduling the multiple projects activities with minimal scheduling time and memory optimization.
- A Fuzzy Random Optimization model using two levels of decision makers is developed for efficiently allocating the resources to the prioritized project activities with improved resource optimization rate.

The rest of the paper organized as follows. In Section 2, the proposed FRODM-PSO model is explained with the help of neat architecture diagram. In Section 3, the experimental setting is discussed with exhaustive analysis of results described in Section 4. In Section 5, a review of different techniques designed for project scheduling and resource allocation is discussed with their limitations. In Section 6, the concluding remark is presented.

2. Fuzzy Random Optimized Dynamic Mean PSO Model for Multiple Project Scheduling

The Fuzzy Random Optimized Dynamic Mean PSO (FRODM-PSO) model is designed with the objective of scheduling the multiple projects' activities of multiple software projects. The overall architecture diagram of FRODM-PSO model is shown in below Figure 1.

Figure 1 Architecture Diagram of FRODM-PSO Model



As shown in Figure 1, FRODM-PSO Model initially performs project scheduling process by using Dynamic Mean PSO algorithm with aiming at reducing the project scheduling time. Then, FRODM-PSO Model is used Fuzzy Random Optimization model for allocating the resources to the scheduled project activities which resulting in improved resource optimization rate. The detailed process about the FRODM-PSO Model is explained in following sub sections.

2.1. Dynamic Mean PSO Model for Project Scheduling

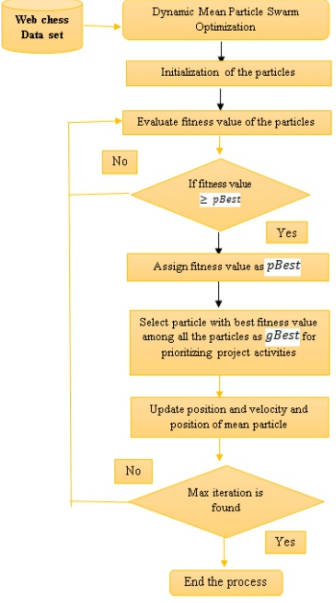
In FRODM-PSO model, a Dynamic Mean Particle Swarm Optimization (DM-PSO) algorithm is developed for scheduling multiple projects activities with minimum cost. Let consider the FRODM-PSO model consisting of numerous project activities which need resource distribution n is represented as the $Project_i$ where $i = 1, 2, \ldots, n$. The number of activities each project involves is a_i Therefore, the project activities set are characterized as $Project_{ij} = Project_{i1}, Project_{i2}, \ldots Project_{ia_i}$ where $j = 1, 2, \ldots, a_i$. Here, $Project_{ij}$ refers activity j of project i. The starting time of project is $StartTime_{ij}$ and the finishing time is $FinishTime_{ij}$ and the intermediate predecessor activity set is PAS_j . Therefore, the scheduling project activities with the minimum cost under constrained resource is mathematically formulated as follows,

$$\min Cost = OC \times max_i max_j (FinishTime_{ij} - StartTime_{ij}) + \sum_{i=1}^{n} \sum_{j=1}^{a_i} Cr_{ijk}^{\rho} \, T_{ij} + \Pi_1 + \Pi_2 + \sum_{i=1}^{n} \sum_{j=1}^{a_i} K_r r_{ijk}^{\rho} \, y_{ij}$$

(1)

From the equation (1), OC denotes the overhead cost per unit time and r_{ijk}^{ρ} is the human resource each unit time needed at normal working time of $Project_{ij}$ whereas C indicates cost of unit human resource at unit normal working time T_{ij} represent the normal working time of $Project_{ij}$ whereas Π_1 and Π_2 signifies the difference between the normal working time of $Project_{ij}$ and the finishing time. Here K_r is unit cost of crashing and Y_{ij} is the crash time of $Project_{ij}$ owing to resource limitations. The project scheduling process using DM-PSO Algorithm is shown in below Figure 2.

Figure 2 of DM-PSO Algorithm Process for Scheduling the Multiple Projects Activities



In DM-PSO algorithm, the inertia weight wt and learning factors i_1, i_2 in the particle velocity equation are varied with iterations. The swarm includes of numerous particles. In DM-PSO algorithm, particles signify a set of project activity priorities therefore FRODM-PSO Model eliminates useless scheduling plan. The particles in DM-PSO algorithm is mathematically represented as follows,

$$\text{Where} \quad 0 \le p_i \le 1 \qquad (2)$$

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The equation (2) signifies the number of particles in swarm. The DM-PSO algorithm $P = particle_1, particle_2, \ldots particle_N$ initially randomly initializes a swarm of particles and then particle moves toward the best positions during the each iteration. The particles move according to their own velocities. For each particle i and dimension j , the velocities and positions of particles can be updated which is mathematically formulated as,

$$velo_i^{t+1} = wt \times velo_i^t + l_1 \times rand_1() \times (pbest_i - pos_i^t) + l_2 \times rand_2() \times (gbest^t - pos_i^t) \qquad (3)$$

$$pos_i^{t+1} = pos_i^t + velo_i^{t+1} \qquad (4)$$

From the equations (3) and (4), $velo_i^{t+1}$ represents the velocity of particle i on iteration $t + 1$ and Pos_i^{t+1} indicates the position of particle i on iteration t . Here, $pbest_i$ denotes the best position p of particle and $gbest^t$ is the best position g of the swarm on iteration t . While particles are updating velocities and positions during iteration, DM-PSO algorithm designed in FRODM-PSO model will be adopted in which the inertia weight and two learning factors are changeable. At the same time, the position and velocity of the mean particle remain the same.

In DM-PSO algorithm, the inertia weight varied in the range of $[0.4, 0.9]$. l_1, l_2 will demonstrate linear variation while the number of iterations is increased. At the starting, l_1 is high. While number of iteration are increased, l_2 goes up and l_1 goes down and particles come down to cognitive learning? Therefore, the values of l_1 , l_2 are mathematically expressed as below,

$$l_1 = 4 \times \frac{Max\ iteration - iterations}{Max\ iteration} \qquad (5)$$

$$l_1 = 4 \times \frac{iterations}{Max\ iteration} \qquad (6)$$

At the same time, a mean particle (i.e. middle particle) is estimated to visit the center of swarm while performing the each iteration. Hence, the mean particle of position is updated by using following mathematical formula,

$$pos_c^{t+1} = \frac{1}{N-1} \sum_{i=1}^{N-1} pos_i^{t+1} \qquad (7)$$

The swarm intelligence of DM-PSO algorithm is determined by using *pbest* and *g*best. Thus, fitness of the particle F is evaluated by using following mathematical formula,

$$fitness = \frac{1}{J(F)} \qquad (8)$$

From the equation (8), $j(F)$ is computed by using the objection function equation (1). Thus, the smaller the total is cost invited by F, while higher the fitness and vice versa. Therefore, DM-PSO algorithm makes possible the particle evolution toward the target with the minimum cost. The algorithmic process of DM-PSO for prioritizing the multiple project activities is explained in below,

// Dynamic Mean PSO Algorithm
Input: Particles
$P = particle_1, particle_2, \ldots particle_N$
Output: scheduling of multiple project activities with minimum scheduling time
Step 1: Begin
Step 2: Initialize the particles of swarm with random position and velocity using (2)
Step 3: For $t = 1\ to\ Max\ Iteration$
Step 4: Compute fitness value of the particle using (8)
Step 5: **If** fitness value ≥ best fitness value $(pBest)$
Step 6: Set current fitness value= $pBest$
Step 7: End if
Step 8: Select the particle with the best fitness value of all the particles as the $gBest$ for prioritizing project activities
Step 9: Update particle velocity using (4)
Step 10: Update particle position using (5)
Step 11: Update position of mean particle using (7)
Step 12: End for
Step 13: End

Algorithm: 1 Dynamic Mean PSO Algorithm

The DM-PSO Algorithm initially initializes the particles with arbitrary position and velocity. Next, for each particle, DM-PSO Algorithm computes the fitness value based on their objective function. If the current fitness value is better than the best fitness value, then DM-PSO Algorithm assign them as pbest. Then DM-PSO Algorithm selects the particle which has the best fitness value as gbest. The velocity and position of the particles is updated for all iteration along with it mean particle position. This process is continual until the maximum iteration is attained. During the each iteration, DM-PSO Algorithm selects the particle with best fitness value among the all particles as best solution for prioritizing the multiple project activities. Therefore, FRODM-PSO Model ensures memory optimization and minimal cost.

2.2 Fuzzy Random Optimization Model

After scheduling the multiple project activities, a Fuzzy Random Optimization model is designed for allocating the resources to the scheduled project activities. For efficient resource allocation, Fuzzy Random Optimization model considers two levels of decision makers (i.e. company manager and project manager). The company manager allocates resources to multiple projects activities with aiming at reducing cost and improving the resource optimization level. The cost include of resource costs and a tardiness penalty. Therefore, the project manager controls the resource cost by scheduling their resource-constrained project with minimum of project duration as the main objective. The tardiness penalty depends on the finishing time of all projects which in turn is computed by the specific project managers during their project schedule. A Fuzzy Random Optimization model for resource allocation is shown in below Figure 3.

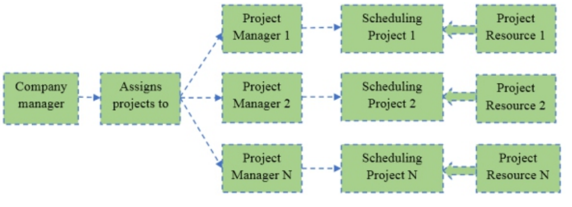

Figure 3 A Fuzzy Random Optimization Model for Resource Allocation

For resource allocation problems, Fuzzy Random Optimization model considers minimal total cost or highest total profit as the objective function. The cost represents the resource costs and the total tardiness penalty of the multiple projects activities. While resources are allocated to a multiple project group, resource costs is take place hence the resource cost for each type of resources in every period can be mathematically expressed as follows,

$$\text{resource cost} = \sum_{n=1}^{N} uc_{kp}\, q_{nkp} \quad (9)$$

From the equation (9), uc_{kp} indicates the unit cost of resource k in period p and q_{nkp} refers the total quantity of resource k in time period p. Besides, while a project finishing time goes beyond its predetermined finishing time, the project tardiness penalty is take places. The overdue time of project n is defined as OT_n which is function on the finish time as follows,

$$OT_n = \begin{cases} T_n - T_n^*, & if T_n \ge T_n^* \\ 0 & otherwise \end{cases} \quad (10)$$

From the equation (10), T_n represents the scheduled finishing time of project n whereas T_n* refers the predetermined finishing time of can be mathematically formulated as,

$$\text{total tardiness penalty} = \sum_{n=1}^{N} opc_n\, OT_n \quad (11)$$

From the equation (11), opc_n denotes the unit overdue penalty cost of project n whereas OT_n indicates overdue time of project . Therefore, the total resource cost can be mathematically formulated as below,

$$\text{total resource cost} = \sum_{n=1}^{N} opc_n\, OT_n + \sum_{p=1}^{P} \sum_{k=1}^{K} \sum_{n=1}^{Nu} c_{kp}\, q_{nkp} \quad (12$$

From the equation (12), uc_{kp} is uncertain owing to the numerous changing influences for example gasoline prices and wages. To handle this uncertainty, uc_{kp} is considered as the fuzzy random variable which represents that the total cost is also a fuzzy random variable. Therefore, the resource allocation using a Fuzzy Random Optimization model is formulated as follows,

$$\min_{R_{nkp}} F_1 = \Pr\{\omega | pos\{\sum_{n=1}^{N} opc_n\, OT_n + \sum_{p=1}^{P} \sum_{k=1}^{K} \sum_{n=1}^{N} c_{kp}\, q_{nkp} \le F_1\} \ge \alpha\} \ge \beta$$

From the equation (13), R_{nkp} denotes the amount of resource k assigned to project n in time period p where α is the predefined confidence level which is provided as an appropriate safety margin by the decision maker. Here, β indicates the predetermined confidence levels related with the possibility measure of the random event. $Pos\{f(\xi) \le 0\} \ge \alpha$. With the aid of Fuzzy Random Optimization model, FRODM-PSO model efficiently allocates the resources to the multiple project activities. The algorithmic process of Fuzzy Random Optimization model for resource allocation is shown in below,

// Fuzzy Random Optimization based Resource Allocation Algorithm
Input: Prioritized Multiple Project Activities
Output: Improved resource optimization Rate
Step 1: Begin
Step 2: For each project activity
Step 3: Measure resource cost using (9)
Step 4: Measure the overdue time using (10)
Step 5: End for
Step 6: Measure the total tardiness penalty using (11)
Step 7: Measure the total resource cost using (12)
Step 8: Allocates the resources to the multiple project activities using (13)
Step 9: End

Algorithm 2 Fuzzy Random Optimization based Resource Allocation Algorithm

With the help of above algorithmic process, FRODM-PSO model effectively allocates the resources to the multiple project activities therefore ensuring the improved resource optimization rate with minimum cost. The project manager controls the resource cost by means of scheduling their resource-constrained project with minimal project duration as the main objective function by using dynamic mean PSO algorithm with minimum project scheduling time.

3. Experimental Setting

The Fuzzy Random Optimized Dynamic Mean PSO (FRODM-PSO) model is implemented in Java Language using Web chess data set. The Web chess data set comprises of numerous PHP Programs to find faults. In FRODM-PSO model, Web chess data set is used for scheduling the project activities with resource constrained. The effectiveness of FRODM-PSO model is measured in terms of resource optimization rate, scheduling time, memory usage.

4. Result and Discussions

In this section, the result analysis of FRODM-PSO model is evaluated. The efficiency of FRODM-PSO model is compared against with two methods namely Event-based scheduler and ant colony optimization (EBS-ACO) algorithm [1] and Particle swarm optimization based hyper-heuristic(PSO-HH) algorithm [2] respectively. The performance of FRODM-PSO model is evaluated along with the following metrics with the help of tables and graphs.

4.1 Measurement of Scheduling Time

In FRODM-PSO model, the scheduling time measures the amount of time taken for scheduling the multiple project activities. The scheduling time is measured in terms of microseconds (ms) and mathematically formulated as follows,

$$scheduling\ time = n * time(scheduling\ one\ project\ activity) \quad (14)$$

From the equation (14), the scheduling time of multiple project activities is obtained where n represents the total number of project activities. While the scheduling time is lower, the method is said to be more efficient.

Table 1 Tabulation for Scheduling Time

Number of Project Activities	Scheduling Time (ms)		
	EBS-ACO algorithm	PSO-HH algorithm	FRODM-PSO model
2	13	11	7
4	18	13	9
6	21	16	11

8	25	20	15
10	28	24	18
12	32	26	20
14	36	29	24
16	38	31	27
18	41	33	29
20	45	36	31

Table 1 reveals the comparative result analysis of project scheduling time using three methods based on the different number of project activities in the range of 2-20. While 10 number of project activities is taken for project scheduling process, proposed FRODM-PSO model takes 18ms scheduling time whereas EBS-ACO algorithm and PSO-HH algorithm takes 28 ms and 24ms respectively. Therefore, the project scheduling time using proposed FRODM-PSO model is lower as compared to other existing methods. Based on the table value, the graph is drawn in below

Figure 4. Measurement of Scheduling Time

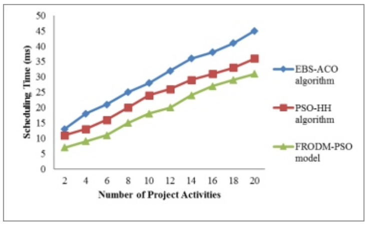

Figure 4 portrays the impact of project scheduling time versus diverse numbers of project activities in the range of 2-20. As illustrated in figure, the proposed FRODM-PSO model provides better project scheduling time as compared to EBS-ACO algorithm [1] and PSO-HH algorithm [2]. Besides, while increasing the number of project activities for scheduling, the project scheduling time is also gets increased using all the three methods. But comparatively, the project scheduling time using proposed FRODM-PSO model is lower as compared to other existing works. This is because of application of Dynamic Mean Particle Swarm Optimization (DM-PSO) algorithm in FRODM-PSO model. In DM-PSO algorithm, the weight and learning factors are varied and a mean particle is computed to visit the center of swarm while accomplishing the each iteration. Simultaneously, during the each iteration, DM-PSO Algorithm chooses the particle with best fitness value among the all particles for scheduling the multiple project activities with minimal cost. This in turn helps for reducing the project scheduling time in an effective manner. As a result, the proposed FRODM-PSO model is reduced the project scheduling time by 64% as compared to EBS-ACO algorithm [1] and 31% as compared to PSO-HH algorithm [2] respectively.

4.2 Measurement of Memory Usage

In FRODM-PSO model, the memory usage measures amount of memory utilized for scheduling and allocating the resources to the multiple project activities. The memory usage is measured in terms of kilobytes (KB) and mathematically formulated as follows,

$$\textit{memory usage} = \textit{total memory space} - \textit{unused memory space}$$

From the equation (15), the memory usage of multiple project activities is obtained. While the memory usage is lower, the method is said to be more efficient.

Table 2 Tabulation for Memory Usage

Number of project activities	Memory Usage (KB)		
	EBS-ACO algorithm	PSO-HH algorithm	FRODM-PSO model
2	21.56	15.11	11.26
4	25.65	18.45	15.65
6	29.78	20.16	18.69
8	33.47	25.87	22.47
10	37.11	28.67	26.98
12	41.01	32.18	28.14
14	43.26	36.59	33.89
16	48.16	40.59	38.78
18	51.36	45.63	43.15
20	55.69	49.62	47.22

The comparative result analysis of memory usage using three methods based on the diverse number of project activities in the range of 2-20 is presented in Table 2. While 16 number of project activities is taken for project scheduling and resource allocation process, proposed FRODM-PSO model consumes 38.78 KB memory whereas EBS-ACO algorithm and PSO-HH algorithm consumes 48.16 KB and 40.59 KB respectively. Hence, the memory usage using proposed FRODM-PSO model is lower as compared to other existing methods. Based on the table value, the graph is plotted in below

Figure 5. Measurement of Memory Usage

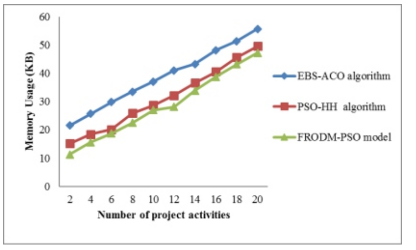

Figure 5 depicts the impact of memory usage of project scheduling and resource allocation versus different numbers of project activities in the range of 2-20. As demonstrated in figure, the proposed FRODM-PSO model provides better memory usage for project scheduling and resource allocation when compared to EBS-ACO algorithm [1] and PSO-HH algorithm [2]. As well, while increasing the number of project activity for project scheduling and resource allocation, the memory usage is also gets increased using all the three methods. But comparatively, the memory usage using proposed FRODM-PSO model is lower as compared to other existing works. This is due to the DM-PSO algorithm and a Fuzzy Random Optimization model employed in FRODM-PSO model. The DM-PSO Algorithm calculates the fitness value based on objective function for prioritizing the multiple project activities with minimal cost. Besides, a Fuzzy Random Optimization model assumes minimal total cost or highest total profit as the decision objective and considers two levels of decision makers for efficient resource allocation process. This in turns supports for reducing the memory usage in a significant manner. As a result, proposed FRODM-PSO model is reduced the memory usage of project scheduling and resource allocation by 44% as compared to EBS-ACO algorithm [1] and 12% as compared to PSO-HH algorithm [2] respectively.

4.3 Measurement of Resource Optimization Rate

In FRODM-PSO model, the resource optimization rate is defined as the process of assigning and scheduling available resources (human, machinery, financial) in most efficient manner with the requirements of the organization in order to achieve established goals. The resource optimization rate is measured in terms of percentages (%).While the resource optimization rate is higher, the method is said to be more efficient.

Table 3 Tabulation for Resource Optimization Rate

Methods	Resource Optimization Rate (%)
EBS-ACO algorithm	74.22
PSO-HH algorithm	82.47
FRODM-PSO model	93.56

Table 3 demonstrates the resource optimization rate result of resource allocation using three methods. From the table value, it expressive that the resource optimization rate using proposed FRODM-PSO model is higher as compared to EBS-ACO algorithm [1] and PSO-HH algorithm [2]. Based on the table value, the graph is designed in below

Figure 6. Measurement of Resource Optimization Rate

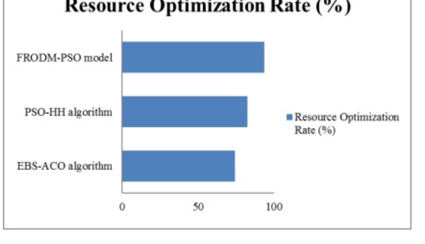

Figure 6 represents the impact of resource optimization rate for project resource allocation versus dissimilar numbers of project activities. As established in figure, the proposed FRODM-PSO model provides better resource optimization rate for project resource allocation when compared to EBS-ACO algorithm [1] and PSO-HH algorithm [2]. In addition, while increasing the number of project activity for resource allocation, the resource optimization rate is also gets increased using all the three methods. But comparatively, the resource optimization rate using proposed FRODM-PSO model is higher as compared to other existing works. This is owing to the Fuzzy Random Optimization model utilized in FRODM-PSO model. The Fuzzy Random Optimization model considers two levels of decision makers (i.e. company manager and project manager) for effective resource allocation in project scheduling where the company manager allocates resources to multiple projects activities with objective of minimizing cost and enhancing the resource optimization rate. While performing the resource allocation process, Fuzzy Random Optimization model suppose that minimal total cost or highest total profit as the decision objective. With the help of this decision objective, Fuzzy Random Optimization model assigns and schedules the available resources to the multiple project activities in order to attain established goals. This in turns supports for improving resource optimization rate in an efficient manner. As a result, proposed FRODM-PSO model is improved the resource optimization rate by 21% as compared to EBS-ACO algorithm [1] and 12% as compared to PSO-HH algorithm [2] respectively.

5. Related Works

Preemptive Resource Constrained Project Scheduling Problem with Weighted Earliness-Tardiness and Preemption Penalties (PRCPSP-WETPP) was designed in [11]. PRCPSP-WETPP reduced the total cost of earliness-tardiness and preemption penalties subject to the precedence relations, resource constraints and a fixed project deadline. However, the average CPU time is high. This issue is addressed in FRODM-PSO model by designing a DM-PSO algorithm for project scheduling process where it determines the mean position of particle to visit the center of swarm during the each iteration for providing the new solutions to scheduling multiple project activities. Therefore, FRODM-PSO model reduced the average CPU time in an efficient manner.

A software project scheduling/rescheduling framework was designed in [12] that support dynamic staffing and rescheduling by using a hybrid approach based on a Genetic Algorithm (GA) and Hill Climbing (HC). Though, the project scheduling performance is not effective. To efficiently scheduling the multiple projective activities, DM-PSO algorithm is built in FRODM-PSO model. Hence, the FRODM-PSO model effectively improves the scheduling process of multiple project activities.

A novel time planning procedure was designed in [13] that discover the feasible start times of activities and the longest paths among start times of activities. However, the resource optimization rate was high. This problem is addressed in FRODM-PSO model through designing Fuzzy Random Optimization model using the two levels of decision makers therefore ensuring higher resource optimization rate. A genetic algorithm integrated with concepts on fuzzy set theory and specialized coding and decoding mechanism [14] to efficiently find the optimal schedule and formulate the correct decision.

Multi-Mode Resource-Constrained Multi-Project Scheduling Problem was solved in [15] to discover a feasible schedule when reducing the total project delay (TPD) and the total make span (TMS). Though, the scheduling time was high. This scheduling time problem is addressed in FRODM-PSO model by constructing a DM-PSO algorithm for project scheduling process where it selects the particle with best fitness value among the all particles for scheduling the multiple project activities which resulting in reduced scheduling time. ACO based software development project scheduling was developed in [16] that permits software project managers and schedulers to allocate most effective set of employees which resulting in reduced cost and duration of the software project. However, it does not consider the employee allocation matrix.

An improved ACO approach with optimal global search using neural approach was designed in [17] to schedule multiple tasks and address the problem of project scheduling. A two-step procedure was developed in [18] where the TCT is applied by using Microsoft excel software to achieve the project deadline considering unlimited resources. But, computational time was high. The higher computational time problem is solved in FRODM-PSO model by using DM-PSO algorithm. A modified multi-mode resource constrained project scheduling model was introduced in [19] for software projects (MRCPSSP) and integrates it into a Scrum project flow. A review of different techniques designed for software project scheduling and the various type of scheduling employed in software projects are discussed in [20].

6. Conclusion

An efficient Fuzzy Random Optimized Dynamic Mean PSO (FRODM-PSO) model is developed for prioritizing multiple project activities of multiple software projects. The main objective of FRODM-PSO model is to achieve efficient project scheduling and resource allocation. This objective is achieved by designing a Dynamic Mean Particle Swarm Optimization (DM-PSO) algorithm for scheduling multiple projects' activities which resulting in minimum scheduling time. DM-PSO Algorithm selects the particle with best fitness value among the all particles as best solution during the each iteration for scheduling the multiple project activities which resulting in memory optimization therefore achieving minimum cost. Besides, a Fuzzy Random Optimization model towards multiple project scheduling using two levels of decision makers is designed for efficiently allocating the resources to the multiple project activities which resulting in improved resource optimization rate. The efficiency of FRODM-PSO model is test with the metrics such as scheduling time, memory usage and resource optimization rate. With the experiments conducted for FRODM-PSO model, it is observed that the resource optimization rate provided more accurate results as compared to state-of-the-art works. The experimental results demonstrates that FRODM-PSO model is provides better performance with an improvement of resource optimization rate by 17% and also reduces the scheduling time by 48% when compared to the state-of-the-art works.

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