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INNOVATIVE HEURISTICS MODELING FOR DYNAMIC PROJECT SCHEDULE OPTIMIZATION

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Abstract
Efficient and effective project management significantly improves the bottom line of the organization and also enhances ultimate service provided to the customer. The dynamic nature of the schedule deviations of the various tasks of the project is a serious issue during project execution stage. Efficient project management is a complex process in our effort to execute it within the schedule and the complexity of the problem increases when more number of tasks and longer duration of the project are involved.. In this paper, an innovative optimization methodology is proposed that utilizes the Particle Swarm Optimization algorithm to generate essential predictive analytics to overcome the impasse in maintaining the optimal project schedule performance.
Index Terms— Project management, Schedule optimization, Performance modelling, Particle swarm optimization (PSO)

I. Introduction

Manufacturing enterprises have been under pressure to competently cope with a market that is rapidly changing due to global competition, shorter product life cycles, dynamic changes of demand patterns and product varieties[1]. Competitiveness in today's marketplace depends heavily on the ability of a firm to handle the challenges of reducing lead-times and costs as well as increasing customer service levels. All these factors have driven business organizations to move towards dynamic schedule performance optimization on various projects undertaken[2].

The task of managing Schedule performance can be a major challenge for organizations which are faced with increasing pressures to execute project Schedule in alignment with planned progress. Earned Value can help analyze a project and the technique integrates cost, time, and the work done (scope) to actually assess the project performance. The Earned Value (EV) can then be compared to actual project Schedule and planned project Schedule to determine project performance and predict future performance trends [4][5]

Particle Swarm Optimization (PSO) is a population-based stochastic global optimization algorithm and the robust performance of the proposed method over a variety of difficult optimization problems has been proved[3] [6]. In accordance with PSO, either the best local or the best global individual affects the behaviour of each individual in order to help it fly through a hyperspace [7]. The ability pf the particles to remember the best position that they have seen is an advantage of PSO. An evaluation function that is to be optimized evaluates the fitness values of all the particles [8].

II. Method and Methodology

A project consists of many tasks and we assume it has 5 tasks for illustrating the proposed model.
In a project there are many tasks involved to be executed . For each task i and for each period j, we calculate the Schedule performance index(SPI) as follows:
SPI ij = EVij/PVij
where
EVij = Earned value which provides estimated value of the work actually accomplished for task i for period j
PVij = Planned value for task i for period j
A database consisting of these data values is created for each period during the course of execution of the project.
How the various tasks of the project perform with respect to cost in alignment with the earned value is the main objective and optimization methodology is developed accordingly as illustrated in figure 1 to move towards dynamic Schedule performance optimization on various tasks of the project undertaken .

The procedures involved in determining the optimal stock levels are illustrated in Fig 1.

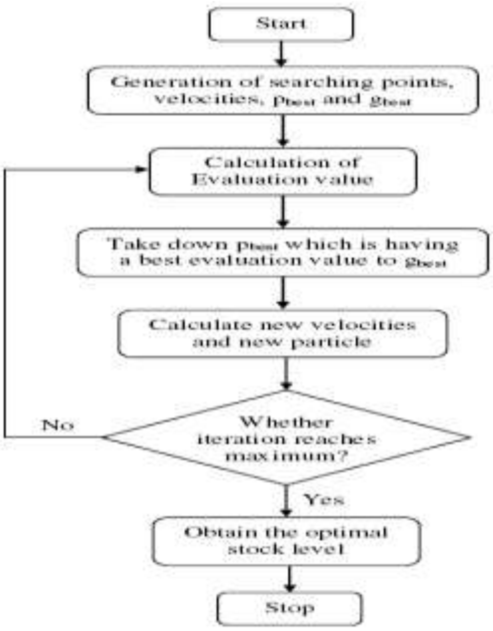

Fig. 1: Particle swarm optimization Methodology

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The PSO methodology is outlined below.
The individuals of the population including searching points, velocities, p_{best} and g_{best} are initialized randomly but within the lower and upper bounds of the SPI values, which have to be specified in advance.
Determination of Evaluation function

$$f(i) = -\log\left(1-\frac{n_{occ}(i)}{n_{tot}}\right); \quad i = 1,2,3,\cdots,n$$

$n_{occ}(i)$ is the number of occurrences of the particle in the record set

n_{tot} is the total number of records that have been collected from the past or total number of data present in the record set.
n is the total number of particles for which the fitness function is calculated.
For every individual, a comparison is made between its evaluation value and its p_{best} .The g_{best} indicates the most excellent evaluation value among the p_{best} . This g_{best} nothing but an index that points to the best individual we have generated so far.

Subsequently the adjustment of the velocity of each particle is as follows:

$$v_{new}(a,b) = w * v_{cnt}(a) + c_1 * r_1 * [p_{best}(a,b) - I_{cnt}(a,b)]$$
$$+ c_2 * r_2 * [g_{best}(b) - I_{cnt}(a,b)]$$

where,

$a = 1,2,\cdots\cdots,N_p$

$b = 1,2,\cdots\cdots,d$

Here, $v_{cnt}(a)$ represents current velocity of the particle, $v_{new}(a,b)$ represents new velocity of a particular parameter of a particle, r_1 and r_2 are arbitrary numbers in the interval $[0,1]$, c_1 and c_2 are acceleration constants (often chosen as 2.0), is the inertia weight that is given as

$$w = w_{max} - \frac{w_{max} - w_{min}}{iter_{max}} \times iter$$

where,

w_{max} and w_{min} are the maximum and minimum inertia weight factors respectively that are chosen randomly in the interval $[0,1]$. Also v_{min} and v_{max} are the minimum and maximum limit for velocities respectively

$iter_{max}$ is the maximum number of iterations

$iter$ is the current number of iteration

Such newly obtained particle should not exceed the limits. This would be checked and corrected before proceeding further as follows,

If $v_{new}(a,b) > v_{max}(b)$, then $v_{new}(a,b) = v_{max}(b)$

if $v_{new}(a,b) < v_{min}(b)$, then $v_{new}(a,b) = v_{min}(b)$

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Then, as per the newly obtained velocity, the parameters of each particle is changed as follows

$$I_{new}(a,b) = I_{cnt}(a,b) + v_{new}(a,b)$$

Then the parameter of each particle is also verified whether it is beyond the lower bound and upper bound limits. If the parameter is lower than the corresponding lower bound limit then replace the new parameter by the lower bound value. If the parameter is higher than the corresponding upper bound value, then replace the new parameter by the upper bound value. For instance,

If $P_k < P_{L.B}$, then $P_k = P_{L.B.}$

Similarly, if $P_k > P_{U.B}$, then $P_k = P_{U.B.}$

This is to be done for the other parameters also.

This process will be repeated again and again until the evaluation function value is stabilizing and the algorithm has converged towards optimal solution.

III. Implementation Results

The analysis based on PSO for predicting optimal Schedule performance has been implemented in the platform of MATLAB .As stated, we have the detailed information about the SPI values for each task of the project for each period .The sample data having this information is given in the Table 1.

Table 1: A sample data of SPI

PI	T1	T2	T3	T4	T5
1	0.3	0.6	1	1.3	1.3
2	0.8	0.8	1.2	1	1.3
3	0.9	0.6	1	1.1	1.5
4	1	0.7	1.1	1	1.4
5	0.8	0.9	1	0.8	1
6	0.9	0.8	1.2	1	1.1

As initialization step of the PSO process, the random individuals and their corresponding velocities are generated.

Table 2: Initial random individuals

T1	T2	T3	T4	T5
0.3	0.6	1	1.3	1.3
1	0.8	1.2	1	1.3

Table 2 describes two random individuals.

Similarly, Table 3 represents random velocities which correspond to each particle of the individual.

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Table 3: Initial Random velocities corresponding to each particle of the individual

T1	T2	T3	T4	T5
0.1350	0.1350	0.1350	0.1350	0.1350
0.0259	0.0259	0.0259	0.0259	0.0259

The simulation run on a huge database of 5000 past records showing evaluation function improvement at different levels of iteration is as follows:

Simulation Result showing evaluation function improvement

For iteration 50: evaluation function = 0.35;
For iteration 80; evaluation function = 0. 45
For iteration 150; evaluation function = 0.65;
For iteration 200; evaluation function = 0.95;

The final individual obtained after satisfying the convergence criteria is given in Table 4.

` Table 4: database format of Final Individual

T1	T2	T3	T4	T5
0.8	0.7	1	1.2	1.3

The final individual thus obtained represents the most emerging pattern for the project schedule performance levels for each task, providing essential information towards optimal project schedule levels.
Based on the essential information provided by the final best chromosome, we get the following inference
SPI=1 indicates actual schedule equals planned progress;
SPI>1 indicates better than expected schedule performance;
SPI<1 indicates lower than expected schedule performance;
SPI<1 means that we have to take remedial measures to control the schedule deviation so as to move towards schedule performance optimization. In this case TaskT1 and Task T2 are not meeting the expected performance level and requires intervention with remedial measures to control the schedule deviation so as to move towards schedule performance optimization.

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IV. Conclusion

Schedule performance management is an important component of project management. As the project has many tasks with respective planned schedules, any schedule deviation will have huge impact on the total project cost. The schedule performance index plays a vital role in the in finding out the schedule deviation and hence gives an inference for control of project schedule. To tackle the complexity in predicting the schedule deviations, we have proposed an innovative and efficient approach based on Particle Swarm optimization algorithm using MATLAB that is aimed at predicting the most probable schedule deviation of the project for the forthcoming period necessitating intervention with remedial measures to control the schedule deviation so as to move towards schedule performance optimization.

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